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THE FINANCIAL RELATIONSHIP BETWEEN THE MUNICIPALITY AND THE WATER UTILITY[1]

By Adolph Kanneberg[2]

A great deal of careful analytical and scientific work has been performed by the Commission for cities, villages and towns, at practically no cost to them, as an aid in establishing the financial relationship between the municipalities and the utilities owned by them. Much of the result of its work in this direction does not appear on the surface. Hence an attempt will be made here to outline some of the developments which have occurred.

The early tendency in the operation of most municipally owned water plants was to handle them as a department of the city like the street, sewer, police or fire departments, etc. The aim of the Railroad Commission has been to get the municipalities to operate their utilities as business propositions separate and distinct from the other municipal departments, the utilities being revenue producing departments whereas the other departments are not organized primarily for that purpose. Practically all but the smaller municipalities owning public utilities have been led to adopt the Commission's plan of procedure based principally upon the provisions of the statutes.

Separate sets of records have been adopted, the utilities following

[1] Presented before the Wisconsin Section meeting, October 11, 1928.

[2] Commissioner, Wisconsin Railroad Commission, Madison, Wis.

the provision of the Commission's Uniform Classification of Accounts. Under this classification the financial records of the municipally owned utilities must be kept on an accrual basis, whereas in all but the very large cities the clerk's and treasurer's financial records show merely cash receipts and disbursements.

It was thought that when the first classification was carefully outlined each utility might be in a position to design its own books. With the progress of time, however, it was found that the accounting procedure actually followed by many municipally owned utilities was assuming such varied phases that it was difficult to secure uniformity of results without the prescription of uniform procedure and uniformity of accounting forms. Likewise, in some instances interpretations were placed upon some of the accounts, due to this confusion, which was wholly foreign to the Commission's original intent. Realizing this difficulty, the Commission in 1912 took up the problem of designing uniform books of accounts and prescribing uniform accounting procedure so far as practical. After considerable study and experiment, a set of forms was designed, so general in nature as to be applicable to practically all municipally owned utilities and available for modification to meet special conditions not provided for. On January 1, 1914, the forms designed and instructions for handling same were made available for distribution.

For several years the Commission expended a large amount of money annually in installing accounting systems, particularly for municipally owned utilities and outlining the procedure to be followed in handling the books and records separate and distinct from the general city or village business. So many municipally owned utilities availed themselves of the Commission's offer to install this system without cost to them, that by 1917 practically all of the larger utilities were in a position to furnish immediate, reliable, adequate and permanent records of their financial and physical operations.

Under the law the city clerk is the legal custodian of the records of the municipality and where the utility is operated under direct council control, as many are irrespective of the provisions of Section 66.06, the clerk will normally have charge of the utility records keeping them separate, of course, from the general city records. However, in instances in which the utility is operated under a water commission or board of public works as provided by law, the records ought to be and usually are in the possession of a member of the Commission or board who is charged with the duty of keeping them.

In many instances the keeping of utility records by the city clerk does not produce entirely satisfactory results. The office being elective is subject to change and in many instances it is found that newly elected city clerks are entirely unfamiliar with the utility business and with the methods of bookeeping employed. It is the usual practice in the larger utilities, therefore, for the utility records to be kept by a duly appointed bookkeeper whose tenure of office is more continuous.

The question of the city clerk acting as secretary of the water commission has been raised several times. It has been held informally by the Attorney General that the statutes relating to cities do not prohibit the city clerk from receiving compensation as such and also as secretary of the utility commission.

In 1923, legislature amended Section 66.06, Subsection 10g of the statutes, to provide for the operation of a municipal utility in cities of the third and fourth class by the Board of Public Works instead of a water commission if so desired. Under the duties of the city clerk the statutes provide that " . . . he shall be ex-officio secretary of the Board of Public Works. . . . "

In view of these provisions there appears to be no question but that the clerk may act as the legal secretary of the utility commission and that his salary may be apportioned between the general city work and the utility work upon a reasonable basis.

All communications affecting the accounts of the water department and the city general fund should be made in writing so that a link will exist in the records of both departments. For example, whenever the city general fund redeems any of the bonds issued for utility purposes the city clerk should immediately inform the department of such redemption in writing.

Where a utility is operated under direct council control such as a water committee and even under the board of public works as organized in some cities, there is often no centralized and definite location of records or control such as is found with the water commission functioning. The Board of Water Commissioners, whose duties are set forth in Section 66.06 of the statutes, is an operating body, a body of directors so to say, while the city is the owner of the property subject to such encumbrances as the city may have incurred in connection with the acquisition of the property.

The authority of the Board of Water Commissioners is limited to operating and maintaining the plant at its present value and it can only

contract to purchase, construct and install extensions, etc., to such plant whenever the same shall have been ordered and funds provided therefore by the city council. On the other hand, the city council is limited in its power relating to the provision of funds in that it cannot make appropriations out of the income derived from the operation of the plant unless those things specifically mentioned in Section 66.06, Subsection 11c have been properly provided for.

MORTGAGE CERTIFICATES FOR NEW WORK

There are many cities and villages in Wisconsin that are so near the constitutional debt limit that in order to finance a pure water supply it must be done by the mortgaging of the plant so constructed instead of as a municipal obligation. In several instances the new water systems have been paid for under mortgage certificates issued under the so-called Nye Act. The mortgage certificate trust indenture must expressly provide that the certificates shall be secured by the water system to be constructed and by no other property. No serious complications arise where the system proposed is entirely new. However, the situation has arisen whereby it was proposed to finance the new water supply and pumping system through mortgage certificates and connect it with the old distribution system. The division of earning is so important in a case like this that it may invalidate not only the mortgage certificate issued on the system so constructed, but prevent the issuance of certificates under this kind of a procedure at all, in cases where a new system is in any way connected with the old.

If the earnings of the new water works can be set up in such a way that we may separate the existing water system from the new, the question of the legality of the mortgage certificate issue can be avoided and thus sustain the law. In other words, it is necessary to adopt a procedure which is not at variance with the decision in State ex rel Portage, 174 Wis. 588.

The Attorney General has ruled that where a city has acquired or constructed a utility property without issuing mortgage certificates or mortgage bonds for that purpose, mortgage bonds or mortgage certificates cannot be issued to finance the extensions since the utility property itself under these conditions is considered as being a part of the security for the general city bonds under the 5 per cent debt limit. As we see it, therefore, there is no way that mortgage bonds or mortgage certificates can be issued to finance extensions of utility property or against existing utility property.

The relation of the Water Commission to the city should be on the same basis as the relation of the utility with all of the private consumers and the city should not receive privileges to which private customers are not entitled. Vice versa, the Water Commission should not receive any considerations from the city which it would not receive from any of its creditors. Instances of these relations are:

(*a*) City general fund fails to pay for fire protection service, water used for street sprinkling, sewer flushing, public drinking fountains, public schools, water used in constructing concrete streets or other city undertakings.

(*b*) Utility fails to pay city allowance for local taxes, office space in city halls; a part of the clerk's salary if he acts as secretary of the commission; or for costs of collecting bills where same is performed by the city treasurer.

Of the 108 municipal plants reporting in 1911 only 57 or 52.78 per cent reported income credited with the service of other city departments. At the present time but very few, and these are practically all small village plants, fail to report income from the service supplied the municipality. The Commission has held that there shall be no free service and hence the municipality should pay for all such service supplied it by the utility.

Instances have been known where the body designated as the Board of Water Commissioners was only a committee of the common council and that the function of the board was merely to exercise the powers of the common council through one of its committees. Other instances have been noted where the information at hand indicated that there existed a legally incorporated Board of Commissioners, but that the board only passed on the bills for the department. Thereafter they were submitted to the city council for payment, checks being issued and signed by the Mayor and clerk and countersigned by the city treasurer. If the Board of Commissioners is created properly, it appears that the procedure outlined above is obviously illegal, as the treasurer under the statutes has no right to honor any orders on the water fund except such as are issued by the Board of Comissioners, signed by the president and secretary thereof.

Raising capital for the original purchase of a water system is provided for in Section 66.06, Subsection 9.

EXTENSION OF SYSTEMS

Extensions of mains may be made either from direct appropriations from the city general fund, special assessments, contributions by

customers directly affected, general city bonds or from surplus earnings of the utility and assets offsetting the depreciating or other reserves. The installation of other equipment may be financed either from general city bonds, direct appropriations from city funds, surplus earnings, etc.

The usual procedure for "providing monies" for construction after a plant has been in operation for some time is as follows:

First, all applications and plans for construction and additions should be submitted to the council by the Water Commission for consideration and investigation. After plans have been examined or drawn by the engineer, estimates made and all facts regarding same passed upon by the council by motion, the council should then refer the entire matter to the Commission and order it to enter into contract with the persons who desire to perform the work and see that the contract is performed in accordance with specifications outlined by it. Simultaneously with the referring of the matter to the commission, the council should provide it with the monies with which to perform the work under one or more of the measures noted above. Monthly the Commission should render a report to the council as to the progress of the work and as to the application of funds.

The equity of a city in a municipally owned plant may be defined as:

> the interest in payment for which the municipality has made an actual appropriation or appropriations out of funds belonging to the municipality as a general administrative body and for which it will not be called upon again in any manner or form to meet any obligations incurred in connection with the acquiring of its title in the utility property.

For example, when the municipality raises funds by taxation for the purpose of acquiring the assets of a utility, the municipality thereby becomes the owner unqualifiedly of its interest or equity in the utility property upon payment of the price. In cases where the funds are raised by a general bond issue, such interest or equity would not be unqualified until such bonds were paid. The funded creditors, therefore, have an interest in the utility which should be shown upon the books of account until all funded obligations incurred in connection with the acquirement of the utility property are paid. As fast as the municipality pays for these obligations, this interest is changed to city equity. If these obligations are paid out of surplus earnings, the surplus account and not the city equity account will show the credit for such payments. However, if the funded obliga-

tions or the extensions to the plant are paid for wholly out of rates in excess of a reasonable rate, such discrimination will result in effect that the city equity will be offset by consumer contributions represented by accumulated surplus and that instead of the general tax payers of the municipality owning the plant, the plant will be owned by the customers. This is a condition which the public utility law expressly seeks to prevent, in that it declares, "every unjust and unreasonable charge for service is prohibited and unlawful" and "any officer of a city who should do or cause to be done or permit to be done any matter, account or thing in the act prohibited or declared unlawful shall be deemed guilty of a misdemeanor . . . " etc.

PAYING DIVIDENDS OUT OF PROFITS

It will be remembered that when the provisions of Section 66.06, Subsection 11c have been complied with the city general fund is entitled to certain surplus earnings of the utility. The Railroad Commission's Uniform Classification of Accounts provides for the transfer of current surplus earnings through an account called "Appropriations to Municipal Funds."

Surplus earnings must not be confused with the amount of cash on hand in the utility fund. Surplus earnings means the remaining portion of the revenues for a certain period after deducting operating expenses, including depreciation and taxes, interest and sinking fund requirements, etc., and is shown as "Surplus" from operation at the close of the income account for each year's business. The cash on hand may include in addition to surplus earnings the funds reserved for depreciation, amortization, current and accrued liabilities, sinking funds, etc.

On several occasions in various communities the common council has attempted to transfer accumulated funds of the utility to the general fund of the city. The question raised in each instance was: has the council authority to make this transfer without the consent of the water commission? The Attorney General has given an opinion relative to this from which the following has been abstracted:

> . . . . since the statute places the water and light commission under the general control and supervision of the city council it would seem that the consent of the commission is not a prerequisite to action by the common council with reference to the funds or management of the utility. The subordinate body can hardly be heard to object that its superior failed to consult it before taking any particular action.

The serious question, however, is whether the common council had any authority under the law to divest the water and light department of its funds. Section 66.06 (11) (c) lays down a very definite program for the use of the funds derived from the income of a municipal public utility plant . . . . clearly, there is no authority to pay income of the utility plant, whether current or accumulated, into the general fund of the city, until the operating, maintenance, depreciation, interest and sinking fund requirements have all been met, together with any requirements there may be for additions and improvements. If, therefore, the fund of $40,000 here in question was built up out of income of the plant, the common council had no authority to place it in the general fund, for your letter expressly states that the total of this $40,000 accumulation was needed for depreciation reserve and for repairs imminently required. . . .

If, however, the $40,000 fund was not built up out of income of the utility,—if, for example, it was simply appropriated by the council to the utility fund from the general fund—I know of no statutory obstacle to its being removed from the utility fund and returned to the general fund. The statute I have just been referring to relates only to the income of the utility and not to funds built up from sources other than income. The general charter law, Section 62.12 (6) prohibits the council from appropriating, and the treasurer from paying out, funds appropriated by law to a special purpose, except for that purpose; but the only fund that is appropriated by law to the payment of maintenance and depreciation charges of the utility plant is the fund built up out of income, hence the prohibition in the general charter does not seem applicable.

The answer to your question therefore seems to me to depend wholly on the manner in which the $40,000 fund was built up. If it was built up out of the income of the plant, then I am satisfied that the payment of the money into the general fund was illegal, under the facts stated by you, and that the municipal officers could be restrained by a court of equity from paying it out for general city purposes, or could be compelled by mandamus to restore it to the water and light fund.

Where a surplus from operation has been accumulated and there appears to be no question that all of the accumulation is needed for the provisions outlined in the statutes, a part of the surplus can be transferred to the general fund as interest or return on the city's equity in the plant. There are many plants which have little or no bonded indebtedness and have only a very small annual construction program which are, therefore, in a position to pay the city a return on its investment from its earnings and still maintain a reasonable schedule of rates.

Several water utilities set up on their books a charge to an interest account for a fixed return on the city's equity in the plant. It is believed that this procedure is not in conformity with the provisions of Section 66.06 or the Commission's Uniform Classification of Accounts. The point has already been touched upon that, after all

conditions have been met, any surplus then remaining may be appropriated by the owner of the utility (the city) as a return on the investment. If no investment has been made, clearly the owner has no title to any return. Also, if nothing remains to be appropriated, the owner can claim nothing. So it may be said that while the city is entitled to appropriate all reasonable income from the operation of the utility, it is not entitled to any so-called commercial interest. Commercial interest carries with it the impression of a fixed rate of return, while all the city would be entitled to is the amount of reasonable difference between total revenue and operating expenses, after having made provision for the statutory requirements.

TAXES ON A MUNICIPALLY OWNED PLANT

The question of taxes on a municipally owned plant has caused considerable discussion. The Commission has recommended that municipally owned utilities report an item as taxes equivalent to what they would pay to the city if they were privately owned. When a municipality undertakes to operate a water plant it operates property which, if privately owned, would contribute taxes to the support of the city and unless this item is shown on the books the true cost of the service is not disclosed by the books. It is the Commission's opinion that instead of the entry of this tax amount causing a report which would be misleading to the tax payers, the tax payers will not have correct information unless this amount is entered.

However, in making this recommendation the Commission has stated that the statutes do not specifically require that provision be made for taxes on a municipally owned plant, but that it has been recommended simply for the sake of having the plant show to the tax payers of the city its true financial status.

The Commission has stated on numerous occasions that it considered the procedure recommended a correct procedure and that failure to comply with the recommendation constitutes the insistence on an improper accounting practice.

The following formula to be used in computing the amount of taxes which municipally owned public utilities should pay to the general fund of the city was determined at a conference between the Tax Commission and Railroad Commission accountants.

$$(A) \times (B) \times (C) = D$$

(A) represents the property and plant value as shown by the utility books *at the beginning of the year*, without taking into consideration the retirement reserve.

(B) represents the ratio of assessed to true value for the city. (The local assessor will furnish this ratio.)

(C) represents the tax rate for local and school purposes, excluding state and county taxes.

(D) represents the amount of tax which the utility should pay.

It should be noted that the tax on the utility will not be included in the tax roll as in that event state and county taxes would have to be paid. This tax matter will be handled simply as a memorandum between the city clerk and the secretary of the Water Commission.

In certain instances where the taxes are accrued on the utility's books and all available funds are needed by the utility for additions or construction purposes, the tax accrued account is cleared by debiting it and crediting the city equity account. The cash that might have been paid, therefore, is used for other purposes.

HANDLING OF CLAIMS

In examining the records of hundreds of municipally owned utilities, a wide variance has been noted in the method of handling claims, particularly with respect to the affidavit requirement on claims. A ruling by the Attorney General on this question it is believed will be of interest.

. . . . . Section 62.12 (8) (a) is in general terms and prescribes a general rule for presenting claims and demands against cities, and applies to all claims and demands against cities except where a different or specific method is provided for as to particular kinds of claims.

Section 66.06 (10) (a) provides a scheme for the management and operation of a municipally owned public utility managed by a nonpartisan board to be created by the council. That provision is clearly mandatory.

Section 66.06 (10) (d) gives power to the council of any city owning such a public utility to provide that the departmental expenditures of such a municipally owned utility may be audited by such commission and paid by the treasurer upon warrants issued by the president and secretary of such commission. This special method of auditing and paying such claims is not mandatory and would not be in effect without formal action by the town or village board or city council, and without such action such claims would be presented, audited and paid the same as other claims against the city, as provided in Section 62.12 (8) (a) of the Statutes.

Many utilities do not require an affidavit. Others not only require a sworn statement but require a dated and signed receipt to be returned subsequent to the payment of the claim.

CONSUMERS OUTSIDE CITY LIMITS

The question has arisen on several occasions whether a municipal utility can be compelled to furnish water at the city limits to a resident of the territory outside of the municipality to be transported by him through a pipe line to his premises.

A municipality which is engaged in furnishing water to private consumers is acting not in a governmental capacity but in a business or proprietary capacity and in so operating is subject to the same obligations as to service as a privately owned utility (State Journal Printing Company vs. City of Madison, 148 Wis. 396–403).

The duty of a utility as to rendering of service ends at the municipal limits of the municipality as to which it holds an indeterminate permit. The entering of a new municipality involves the application for, the granting of, and the acceptance of a permit from the municipal authorities of that unit. The application for such a permit is voluntary and the utility cannot be compelled to assume such an undertaking against its will, nor can the municipal authorities be compelled to grant such a permit, that action being discretionary.

Examination of Section 66.06 (12) of the Statutes will indicate that this statute is permissive and apparently involves the exercise of discretion on the part of the municipal utility and until such discretion has been exercised and service actually rendered beyond the municipal limits, thereby assuming the duty of serving, it is very questionable whether this commission would have any jurisdiction to require such an extension. Clearly under the provisions of Section 196.50 (3) no such extension could be made in an adjoining community where there was in operation a public utility under an indeterminate permit rendering a similar service without securing a Certificate of Public Convenience and Necessity from the Commission, and here again, no such Certificate of Public Convenience and Necessity could issue except upon voluntary application of the municipal utility desiring to make such an extension.

A person residing outside of the city or village and owning no property therein has no status to demand the privileges nor can he be forced to undertake the duties incident to being an inhabitant or freeholder within the city limits. To hold that the rendering of

service to such outsider was not an extension of the system for the service of the inhabitants of the outside community would be far-fetched and against public policy. The serving of a consumer, therefore, through a private line extending outside of the municipal limits, is an extension of the municipal water works system into that community and is a matter of discretionary policy to be exercised by the municipal authorities and which cannot be compelled by a regulating commission.

In making contracts for rural service where the city has extended its service outside its corporate limits it is believed that these contracts may properly be signed for the city by the Water Commission through whatever officer or agent it designates, such as the superintendent. In other words, they will be handled in the same way as contracts with new customers within the city.

In certain instances the situation was somewhat complicated by the fact that the question was raised as to whether the common council had ever authorized the extension of service into the adjoining townships, but that the town permits were applied for and granted to the city without action by the common council. To clarify the matter action was had by the council.

LEGAL PHASES OF FINANCING MUNICIPAL WATER SYSTEMS IN WASHINGTON[1]

By Bruce C. Shorts[2]

Liberal provisions are found in the Constitution and laws of the State of Washington for the issuance of securities for financing municipal water works systems. Generally speaking, securities for the purpose mentioned may be divided into three classes, as follows: First, general obligation bonds; second, bonds and warrants payable solely from revenues; and, third, bonds and warrants payable solely from assessments on benefited property.

CONSTITUTIONAL PROVISIONS

The law pertaining to the subject is found in the Constitution, the statutes, and the decisions of the Supreme Court. The principal constitutional provision is Section 6 of Article 8, entitled "Limitations upon Municipal Indebtedness," which provides as follows:

> No . . . . city, town, or other municipal corporation shall for any purpose become indebted in any manner to an amount exceeding one and one-half per centum of the taxable property in such . . . . city, town . . . . or other municipal corporation, without the assent of three-fifths of the voters therein voting at an election to be held for that purpose; nor in cases requiring such assent shall the total indebtedness at any time exceed five per centum on the value of the taxable property therein to be ascertained by the last assessment for state and county purposes previous to the incurring of such indebtedness, except that in incorporated cities the assessment shall be taken from the last assessment for city purposes. . . . . Provided, further, that any city or town with such assent may be allowed to become indebted to a larger amount, but not exceeding five per centum additional, for supplying such city or town with water, artificial light, and sewers when the works for supplying such water, light, and sewers shall be owned and controlled by the municipality.

It will be noted the limit is a certain per centum "on the value of the taxable property therein to be *ascertained by the last assessment*." The limitation so expressed sounds clear and simple, but a decision of

[1] Presented before the Pacific Northwest Section meeting, November 16, 1928.

[2] Attorney, Seattle, Wash.

the Supreme Court was necessary to interpret the meaning of the words. We have a statute which provides "all property shall be assessed fifty per cent of its true and fair value in money" (Code Section 11097-52). If the Assessor follows the statute, he must first ascertain the true and fair money value of taxable property, and then assess it at 50 per cent of such value. In the case of Hansen v. Hoquiam (95 Wash. 132, 163 Pac. 391) decided by our Supreme Court in 1917, it was held the constitutional limitation of "five per centum of the value of the taxable property therein to be ascertained by the last assessment" means 5 per cent of the "actual value" and not 5 per cent of the "assessed value."

It so happened our Legislature was in session at the time the decision was rendered, and before the adjournment of the session an act was passed (Ch. 143, Laws, 1917, Code Section 5605) limiting municipal indebtedness without popular vote to 1.5 per cent of "the last assessed valuatioh of the taxable property in such taxing district" and with such vote, to 5 per cent of such last assessed valuation, with an additional 5 per cent for water, light, and sewers. By such law the term "the last assessed valuation of the taxable property in such taxing district" was defined to mean the aggregate assessed valuation of such taxing district as placed on the last complete and balanced tax rolls of the county next preceding the date of contracting the debt or incurring the liability. In the case of State ex rel School District No. 102 v. Clausen (116 Wash. 432, 199 Pac. 752, decided July 19, 1921) the Supreme Court sustained the legality of the act.

VOTE REQUIRED

Both the Constitution and the statute prohibit any municipal indebtedness in exess of 1.5 per cent limit "without the assent of three-fifths of the voters therein voting at an election to be held for that purpose." It frequently happens that a debt proposition is submitted to the voters at a general election. At such an election many voters who vote for various state, county, or municipal officers, forget or neglect to vote on the debt proposition. In the case of Strain v. Young (85 Wash. 578, decided in 1901) it appeared a bond proposition submitted to the voters at a general election did not receive the assent of three-fifths of all the voters voting at the election, but did receive the assent of three-fifths of all the voters who actually voted on the bond proposition. The Supreme Court held the vote required to carry the proposition was three-fifths of those actually

voting on the proposition. The same question went to the court a second time (Fox v. Seattle, 42 Wash. 74, decided 1906) and the Supreme Court adhered to its ruling in the Strain case.

In 1925 the Legislature passed an act (Code Section 5646-1) providing that no general obligation bonds of any city or town upon which a vote of the people is required shall be issued unless the total vote cast upon such proposition shall exceed 50 per cent of the total number of voters voting in such municipality at the general county or state election next preceding the bond election. The purpose of this act is wholesome. The three-fifths vote previously required to carry a bond issue still applies, but, in addition under the act, the total vote required on a bond issue must exceed the 50 per cent requirement established by the act.

In practice I find that municipalities now hesitate to call special bond elections, realizing the difficulty and improbability of persuading the required 50 per cent of the voters to turn out and vote at such an election.

COMPUTATION OF DEBTS

It will be noted that "the total indebtedness at any time" is limited to 5 per cent of the assessed valuation, with provision for an additional 5 per cent for water, artificial light, and sewers. The Supreme Court has been called upon many times to interpret the words "total indebtedness." Prior to 1917 the only rules for computing municipal indebtedness were the principles of law applicable thereto as announced in the Supreme Court decisions. In 1917 the Legislature passed an act (Code Section 5605) prescribing the manner of computing indebtedness.

> Whenever it shall be necessary to compute the indebtedness of a taxing district for bond or any other indebtedness purposes, taxes levied for the current year and cash on hand received for the purpose of carrying on the business of such taxing district for such current year shall be considered as an asset only against indebtedness incurred during such current year which is payable from such taxes or cash on hand; provided, however, that all taxes levied for the payment of bonds, warrants, or other proper debts of such taxing district shall be deemed a competent and sufficient asset of the taxing district to be considered in calculating the constitutional debt limit or the debt limit prescribed by this act for any taxing district . . . .

The computation of municipal indebtedness is a very involved proceeding and necessitates a most careful study and analysis of all items of assets and debts.

CLASSIFICATION OF DEBTS

Debts up to the 1.5 per cent limit may be incurred without the voters' approval for general purposes. An additional debt of 3.5 per cent may be incurred for general purposes with the assent of the voters, and a further additional debt of 5 per cent for water, artificial light, and sewers may be incurred with the assent of the voters. These three classifications of municipal debt have been the subject of much litigation.

If a city in debt to its 1.5 per cent debt limit incurs additional debt with the assent of its voters, it is manifest such additional debt cannot be classed as falling within the 1.5 per cent debt limit. But assume a city which might incur $100,000 debt without exceeding the 1.5 per cent debt limit, being at the time entirely free from debt, secures the assent of its voters to incurring a debt of $150,000. How would such a debt be classified? Would $100,000 of the debt be classed in the 1.5 per cent limit and the remaining $50,000 in the 3.5 per cent limit, or would all the debt automatically fall within the second limit? As debts within the 1.5 per cent limit are reduced by payment, should debts in the 3.5 per cent limit be automatically re-classified into the 1.5 per cent limit to the extent of such reduction? These are not trick questions; they have arisen, and are constantly arising in this state. Our Supreme Court has adopted the rule that a debt must be classified in accordance with the intention of the corporate authorities at the time such debt was incurred. The mere voting of a debt does not automatically take the debt so incurred out of the 1.5 per cent limit. The corporate authorities, at the time of incurring a debt usually fail to express any intention respecting its classification. In such cases, unless from other attending circumstances the classification is reasonably clear, it is necessary to resort to litigation to have the debt properly classified. Our Supreme Court has been called upon a great many times to classify municipal indebtedness. Many of such cases are reviewed in the case of State ex rel Clallam County v. Clausen, 82 Wash. 137, 143 Pac. 876.

Respecting the additional 5 per cent allowed for water, artificial light, and sewers by both the Constitution and the statutes, our Supreme Court has held there is not an equal allocation of this additional 5 per cent to water, light, and sewer, and has permitted the incurring of the entire additional 5 per cent for water alone (Langdon v. Walla Walla, 112 Wash. 446, 936 Pac. 1).

Since the furnishing of water is a strictly municipal purpose, it follows that indebtedness to the full extent of the 1.5 per cent limit and the additional 3.5 per cent limit and the additional 5 per cent limit, a total of 10 per cent of the assessed valuation, may be incurred for water. In fact, our Court held in the recent case of McCarthy v Kelso by a five to four decision (129 Wash. 121, 223 Pac. 151) that a city in debt to the full 10 per cent constitutional limit, might incur further debt for the purpose of installing a water filtration plant deemed necessary by the State Board of Health for the preservation of the health and lives of the residents of a city.

PUBLIC UTILITIES ACT

We have in this state a law commonly known as the "Public Utilities Act." It was first enacted in 1890 as a law relating to "internal improvements." Until 1897 only general obligation bonds could be issued under such act. In that year the act was amended to provide also for the issuance of bonds payable solely from a special fund, into which should be set aside for the payment of the bonds a fixed proportion of the revenues or proceeds to be derived from a particular utility. In 1909 the act was further amended so as to permit setting aside into such a special fund, out of the gross revenues of a utility, a fixed proportion of such revenues, or a fixed amount out of a fixed proportion, or a fixed amount without regard to any fixed proportion. The act has been amended numerous times in other respects. It is the most important law in this state conferring authority on cities and towns to construct and finance water systems. Needless to say, the act has given rise to much litigation.

In the year 1895 in the case of Winston v. Spokane (12 Wash. 524, 41 Pac. 888) our Supreme Court held a city incurred no debt by the issuance of bonds and warrants payable solely from the revenues of its water system. Following this decision and because of it, the "Public Utilities Act" was in 1897 amended to expressly authorize the issuance of such bonds and warrants. In the many cases decided since the amendment, our Supreme Court has consistently adhered to its decision in the Winston case. It follows that the constitutional and statutory limitations upon municipal indebtedness do not apply to such bonds and warrants.

The act (Code Section 9488) expressly authorizes any city or town within the State

to construct, condemn and purchase, purchase, acquire, add to, maintain, conduct and operate waterworks, within or without its limits, for the purpose of furnishing such city or town and the inhabitants thereof, and any other persons, with an ample supply of water for all uses and purposes, ... with full power to regulate and control the use, distribution and price thereof.

The act further provides (Code Section 9489) that whenever the corporate authorities of any city or town shall deem it advisable that the city or town purchase, acquire, or construct a water works system or make any additions thereto or extensions thereof, they shall provide therefor by ordinance, which ordinance shall specify and adopt the system or plan proposed and declare the estimated cost thereof as near as may be, and the same shall be submitted for ratification or rejection to the qualified voters of such city or town at an election. Under certain conditions such elections are not necessary in first-class cities. The authority conferred by the act is: first, the power to acquire by construction or purchase; second, the power to maintain, conduct, and operate; and third, the power to make additions, betterments and extensions. Under the act both general bonds and special fund revenue bonds may be issued to pay for acquisitions, additions, betterments, and extensions. Such securities, however, cannot be issued to maintain, conduct, and operate the system. The act contemplates that costs of maintenance and operation shall be paid currently, either out of revenues or tax levies; and this has been the source of much litigation which will be mentioned later.

It is often very difficult to ascertain whether a proposed improvement is maintenance or a betterment. Our Supreme Court has not rendered any decision on the subject. It is a question, however, which is bound to cause litigation.

SYSTEM OR PLAN

Under the act the ordinance must "specify and adopt the system or plan proposed" and "declare the estimated cost thereof, as near as may be." It seems clear no reliable estimate of cost can be made unless and until the system or plan has been reasonably well developed. Voters cannot vote intelligently unless the proposed system or plan is fairly well described. Lawyers and judges prefer as definite a system or plan as is possible; whereas, engineers desire as elastic a plan as is legally possible. Our Supreme Court has said:

The statute requires that a distinct plan of improvement must be set forth. We think it is contemplated by the statute that the system or plan proposed

need be specified only in such general terms as will fairly inform the voters of the general nature and extent of the proposed improvement . . . . Just how far into details such a plan must go, is, of course, governed by no hard and fast rules.

In the case of George v. Anacortes (147 Wash. 242, 265 Pac. 477), our Supreme Court enjoined the city from constructing a portion of the system in a manner at variance with the plan submitted to and approved by the voters, saying the project was one

. . . . composed of several items related to each other and endorsed and approved as a whole by the voters. There is no way of knowing just what portion of the project appealed to the voters. It may be that the laying of the main on 20th Street was considered of primary importance to a great many, and if that item had not been included they would have refused endorsement of the project. . . . . When a plan has been presented to the voters and approved by them, portions may not be abandoned at the will of the city officers and the balance proceeded with.

The system or plan must not combine unrelated improvements. In the case of Dole v. Aberdeen (131 Wash. 516, 230 Pac. 401) it appeared the city desired to establish a new source of supply for its water system by constructing a dam at a strategic point on a river, thereby creating a large storage basin. As part of the project the city proposed to use the impounded water to develop electric power for municipal purposes. The water, after passing through the power house, was then to be diverted into supply mains of the water system. The court condemned the entire project on the ground that two unrelated improvements were unlawfully combined as one. In the case of Langdon v. Walla Walla (112 Wash. 446, 193 Pac. 1), the city proposed to extend its water works system by constructing, first, a large storage reservoir in the city and connecting same with the existing distributing system, and, second, by acquiring a new source of supply in the State of Oregon and connecting same by a pipe line with the existing system. It was contended that the proposed reservoir was a proposition so independent of the other proposition that, in legal effect, two separate propositions were combined in one. In disposing of this contention, the court said:

We cannot agree with this view of the submission of the proposition since all of the things proposed to be done have to do with additions, betterments and extensions to the city water works system as a whole.

In the case of Tulloch v. Seattle (69 Wash. 178, 124 Pac. 481), our Supreme Court approved the submission of an alternative proposition to acquire an existing system or construct a new one.

MAINTENANCE AND OPERATION

In cases where revenue bonds are issued, it is necessary the ordinance should create a special fund and obligate the city to set aside into such fund at stated periods, portions of the revenues to be derived from the utility. The act (Code Section 9491) requires that:

> in creating any such special fund, the corporate authorities shall have due regard to the cost of operation and maintenance of the plant . . . . and shall not set aside into such special fund a greater amount or proportion of the revenues and proceeds than in their judgment will be available over and above such cost of maintenance and operation. . . . .

It is apparent the system must be maintained and operated in order to produce any revenue. It would appear that operation and maintenance costs should be a first charge upon the revenue. However, bond buyers are generally not willing to purchase bonds payable solely from revenues without some limitation upon the amount of the gross revenues which the city authorities may divert and expend for maintenance and operation.

In the case of Twitchell v. Seattle (106 Wash. 32, 179 Pac. 127) a full discussion of this question is found. The city acquired a municipal street railway system and made payment therefor wholly by the issuance of special fund revenue bonds. The ordinance creating the special fund obligated the city semi-annually to set aside into such fund for the payment of the bonds out of the gross revenues of the system certain fixed amounts, which amounts

> . . . . . shall constitute a charge upon such gross revenues superior to all other charges whatsoever, including charges for maintenance and operation; . . . . even though the balance of such gross receipts thereafter remaining may be insufficient to pay the cost of maintaining and operating such system. . . . .

The ordinance also contained the following recitation:

> The gross revenues to be derived from the operation of the . . . . system . . . . will be sufficient in the judgment of the council . . . . to meet all expenses of operation and maintenance . . . . and to permit the setting aside into a special fund out of the gross revenues of the entire system amounts sufficient to pay the interest on the bonds . . .,. and to pay and redeem such bonds at maturity.

It was contended that by the ordinance the city had not given "due regard to the costs of operation and maintenance;" but, on the contrary, had wholly disregarded such costs by making the bonds a charge on the gross revenues superior to the costs of maintenance and operation. The Supreme Court sustained the legality of the ordinance and the bonds issued under it on the theory that by statute it was the duty of the council, and not the court, to exercise such "due regard;" and, since the ordinance expressed the judgment of the council in the matter, the court would assume such judgment had been reached after the exercise of such "due regard."

It was not long, however, before it became manifest that the council had not exercised "due regard." The gross revenues of the system were not sufficient to pay costs of maintenance and operation and also pay interest and principal of the bonds; and the city attempted to pay operating and maintenance charges out of its general funds raised by general taxation. In the case of Asia v. Seattle (119 Wash. 674, 206 Pac. 366), the following question was presented to the Supreme Court:

> May the city voluntarily or involuntarily encroach upon its general fund, or otherwise place upon the taxpayers the burden of meeting deficits of any kind incurred by reason of the carrying out of the plan of purchase or the operation and maintenance of the system thereunder?

The court held the original plan of acquisition contemplated payment for the system wholly in special fund revenue bonds payable solely from revenues, and that

> all obligations arising from the acquisition, operation and maintenance of the utility must be met from its revenue, and, in any event, by no action of the city or its officials can the burden be shifted to the shoulders of the taxpayers, who have had no opportunity to say whether they will or will not accept the hazard.

This decision forced the city to exercise every possible economy in the operation of the system, and it is only fair to say that up to the present time, even in the face of decreased revenues, the city has been able out of such revenues to maintain and operate the system without defaulting in the payment of principal or interest of the bonds. Following the decision in the Asia case, attempts were made in both the state and federal courts to have costs of maintenance and operation decreed to be a first charge upon the gross revenues of the system. All such attempts have been unsuccessful.

SALE OF BONDS

All general bonds under the statute (Code Section 5583-1) must be advertised for sale for four consecutive weeks and sold to the best bidder. No general bonds may be sold at less than par and accrued interest, and no discount or commission can be allowed or paid on the sale of any such bonds.

Special fund revenue bonds may be sold in such manner as the corporate authorities shall deem for the best interests of the city, and may be issued "at par thereof" in payment for the construction or acquisition of the utility upon the revenues of which the bonds are a charge.

Both the general and the revenue bonds may bear interest not exceeding 6 per cent annum payable semi-annually. The general bonds

> shall never be issued for a longer period than thirty years from the date of issue and shall, as nearly as practicable, be issued for a period which will be equivalent to the life of the improvement to be acquired by the use of the bonds. . . . . The various annual maturities shall commence with the second year after the date of issue of such bonds, and shall (as nearly as practicable) be in such amounts as will, together with the interest on all outstanding bonds, be met by an equal annual tax levy for the payment of such bonds and interest.

Special fund revenue bonds may be payable at such times and places as the corporate authorities of the city or town shall determine. Such bonds may be sold at a discount, provided the discount is not so great as to require the city to pay more than 6 per cent on the money actually received. Our State Bureau has a method of its own for figuring this discount which seems to be somewhat at variance with standard bond tables; and intending bidders, before submitting bids, should acquaint themselves with the methods used by the Bureau.

ASSESSMENT BONDS

The time alloted to this paper will not permit a discussion of the various statutes and decisions relating to the creation of local improvement districts in connection with municipal water works systems and the issuance of assessment bonds of such districts; nor have we time here to discuss the laws and decisions relating to the organization of water districts and the financing of water works within such districts. It is sufficient to say that both these subjects have been fruitful of much litigation and that intending purchasers of securities of such districts should acquaint themselves with the laws and decisions on the subject before taking on definite commitments.

DIVERSION OF FUNDS FROM WATER DEPARTMENTS FOR OTHER MUNICIPAL PURPOSES[1]

By Howell Wright[2]

The history of the development of publicly owned water works is contemporaneous with that of an aggressive movement to divert the revenues of such utilities, either directly or indirectly, from their proper channels and legitimate uses. That such diversion is neither limited nor academic is evidenced by the frequent appearances of articles touching on the subject in the various water works and technical journals. In the topical discussion presented before the Buffalo Convention of 1926, Grobbel states that, from a study of nearly one hundred cities in the United States, he found that there is " . . . . diversion in almost all of the cities studied on account of their not only accepting but demanding free service." The use of water works funds for such service or for other than strictly water works purposes is not only contrary to sound administration, but is a positive menace to the very structure upon which the operation of the water works business is based. It is a blot upon municipal ownership and operation and when such diversion appears in the form of subsidies to other municipal departments, as seems to be common practice, it may be properly called "legalized imposition."

This paper unfolds a brief story of the diversion of water works funds as it applies to a number of representative cities throughout the United States. In the main it is a story of "free water." The study of this problem is worthy of the best efforts of the American Water Works Association. Its solution is vital to the continued operation of the water works as an active self sustaining business or public utility, as well as the efficient operation of other municipal departments. The absolute necessity for such a solution is father to the fact that the problem can be solved. If this Association, which is the largest representative of the water works interests in this country, is aroused to energetic action and to the extent of taking

[1] Presented before the San Francisco Convention, June 13, 1928.

[2] Director, Department of Public Utilities, Cleveland, Ohio.

the initiative in forming uniform plans for the abatement and final elimination of the diversion of water works funds for other purposes, then this paper will not have been written in vain.

ATLANTA, GEORGIA

The water works department of Atlanta, Georgia, is operated in general as though it were a tax supported department. All revenue is placed in the general fund and all moneys for operation and maintenance or extensions and enlargements are appropriated either directly or indirectly from this fund. Water is furnished free for fire protection, public schools, parks, public buildings, cemeteries, street sprinkling, hospitals and all city institutions. It is not furnished free for parochial schools.

BALTIMORE, MARYLAND

Water rents are diverted into the general revenues of the City but loan funds are not. Appropriations are made annually for the Water Bureau for operation and fixed charges. Deficits, if any, are made from the tax levy and any surplus is diverted into the general revenue. The City pays for a part of the water it uses for park purposes. Water, however, is furnished free for public schools, fire protection, public buildings and street sprinkling. Parochial schools and cemeteries pay for all the water they use.

About $450,000 or about 13 per cent of the total annual revenue is diverted from water works funds in the form of free services. The Water Bureau pays no taxes nor does it pay its share toward the upkeep of other city departments which may render it service.

BOSTON, MASSACHUSETTS

Water is furnished to Boston by the Metropolitan District Commission. The City does not pay the Commission for any water used for public schools, fire protection, parks, public buildings, nor street sprinkling. Water is not furnished free to parochial schools nor cemeteries. The quantity of water furnished free is about 1 per cent of the total used in Boston. The Commission does not pay anything towards the upkeep of City departments which may render it service and is entitled to receive moneys out of taxes in case of deficit growing out of operation and maintenance.

BUFFALO, NEW YORK

Aside from a small quantity of water furnished free to the State Teachers College and State Hospital for the Insane, there is practically no diversion of funds of any character, the approximate annual cost to the Water Division for all free services not exceeding $5,000. This is less than 0.2 of 1 per cent of the total revenue. The Water Division does not pay any money toward the upkeep of any other City department which may render it service.

CHARLESTON, SOUTH CAROLINA

The Water Department of the City of Charleston, South Carolina is administered independent of the City Council under State Law. The Commission handles all of its own funds acting as its own sinking fund commissioners. The law provides that the interest on bonds for original purchase or construction and sinking fund for retirement of these bonds shall be taken care of by assessment in the general tax levy if necessary. All fire hydrants and all water up to 300,000 gallons a day are paid for. There are times when water in excess of this quantity is used and for such excess the water works has never been paid. Usually the diversion of funds represented by this excess is small. The Water Commission has voluntarily contributed a portion of the surplus funds to the general sinking fund. The maximum amount thus contributed in any one year has been $40,000.

CHICAGO, ILLINOIS

Chicago does not permit direct diversion of water works funds. The water department does however furnish water free of charge for public and parochial schools, fire protection, parks, street sprinkling and public buildings. It receives no money from taxes, but pays its share toward the upkeep of City tax supported departments which render it service. There were diverted from the water works funds in 1927 through free service, nearly $2,125,000 or about 16.5 per cent of its total revenue.

CLEVELAND, OHIO

The water works of the City of Cleveland, during the year 1926, furnished to the city and suburbs a total of 8,245,365,000 cubic feet of filtered water. Of this quantity, there were approximately 430,000,000 cubic feet for which the Water Division received absolutely no pay. If this Division had been paid for its product at

the present rate of 60 cents per 1,000 cubic feet, it would have added to its annual revenue approximately $260,000. This diversion from the funds of the Water Division is made up of non-metered water furnished free of cost to the tax supported city departments for fire protection, street cleaning, sewer flushing, and for use in parks and playgrounds and metered water furnished free to public schools, parochial schools, public buildings, city cemeteries, city markets, public libraries and charitable institutions.

The amount of non-metered water used for fire protection, street cleaning, sewer flushing and for parks and playgrounds, cannot be estimated with any degree of accuracy. The tendency, however, has been to err on the side of conservatism and, to that extent, the diversion of funds is understated. The amount involved, however, is probably a comparatively small percentage of the total and cannot therefore affect any conclusions reached. On the basis of the quantity of water estimated, the annual loss to the Water Division for water furnished for the foregoing City functions, all of which are in connection with some tax-supported department, is approximately $40,000.

Public schools. While it has been necessary to resort to estimation in our analysis of certain previously mentioned factors involved in this discussion of the Cleveland situation, the expediency has been avoided in the case of public and parochial schools, hospitals, charitable institutions, public buildings and cemeteries. These consumers are all metered and the amount of the diversion of funds in these particular cases is within the limit of accuracy of the measuring devices used. These amounts bulk large in total and the legislative body (State and City) was the medium through which most of the diversion takes place. The governing body of the City provided in 1909 "Rules and Regulations" for the use of water. Rule 5 of these regulations stipulates that:

> Water shall be furnished free for market houses, public school buildings, and other public buildings belonging to the City, and all hospitals, asylums, and other charitable institutions devoted to the relief of the poor, the aged, infirm or destitute persons, or orphan children, upon the following conditions:
>
> The following average daily per capita allowance of free water, based on the average number of inmates and attendants, shall be granted as a maximum free of charge to such institutions, to wit:
>
> Public schools, 15 gallons per capita, for the average attendance per day during such days as schools are in session..............................
>
> ....
>
> All such institutions as enumerated in the foregoing shall *pay* for all water used or that passes through the meters supplying said institutions, etc., at the City meter rate, for all consumption above the maximum.

While these regulations unquestionably permit the use of free water for the public schools, the natural inference would be that, if the public schools used more than 15 gallons per capita per day, they would have to pay the Water Division for all in excess of that maximum. As a matter of fact, however, no such payments have ever been made, although this excess amounted to over 188 in 1924, over 184 in 1925 and nearly 216 per cent in 1926. Until recently it was held that "under the law, Boards of Education cannot be compelled to pay for water." The Supreme Court of the State of Ohio has just decided by a majority vote that they can be made to pay. Unfortunately for the Cleveland Water Division, there are certain peculiarities in connection with Ohio law and it is not yet definitely known that this decision is yet enforceable in this district.

During the year 1926, the total value of the water furnished free to the public schools amounted to $105,538.90. The value of the water furnished during the same year in excess even of that allowed by the Council ordinance of 1909 was $72,138.56.

Parochial and private schools. Free water is furnished to parochial and private schools up to the same maximum of 15 gallons per capita per day as is allowed to public schools. Under this regulation, water was furnished free at water works expense during 1926, to the value of $8,614.70.

Charitable institutions and hospitals. Rules and Regulations provide that all charitable institutions and hospitals are entitled to free water up to a maximum of 40 gallons per capita per day, for the former and 75, for the latter. In accordance with this stipulation, the Water Division lost, during 1926, a total revenue of $56,407.60, of which $39,906.80 went to hospitals and the remainder to charitable institutions.

City markets, cemeteries, and golf courses. City markets, cemeteries and golf courses are supposedly self-sustaining divisions connected with tax-supported departments, yet they pay not one cent for water. There was diverted from water works funds during 1926 to furnish these divisions with free water a total of $5,947.80, of which $4,266 was for the markets, $1,630.80 for the cemeteries, and $51 for golf courses.

Private cemeteries. There are a total of 16 private cemeteries in the Cleveland district. Of these sixteen, four are furnished with water free of cost. Water to the value of $6,256.10 was furnished these cemeteries during 1926. With the exception of one, no authoriza-

tion by Council has apparently ever been made for this practice. In the case of this exception, the City Council in 1895 passed a resolution exchanging "free water in perpetuity for a certain strip of land to be used for street purposes." Since this contract, the Water Division has furnished free water costing $38,410.90 and the demand for water is steadily increasing.

Public buildings. The amounts of money which may be diverted from water works funds in the form of free water for public buildings, such as police stations, jails, workhouses, fire engine houses, etc. is limited only by the needs of the institutions. The celebrated Rule 5, previously mentioned, states that water shall be furnished free of charge to "Police Stations and Jails, Work Houses, Fire Engine Houses, Market Houses, Public Bath Houses and other public buildings up to a maximum as may be estimated by the Superintendent of the Water Department." Under this rule, 35 police stations, 21 fire stations and 16 libraries were furnished during 1926 with water, having a value of $30,280.12. The City Hall bill should have been $1,791 during the same period, while that for the market houses is, as previously noted $4,266.

It should not be considered that the figures given in the preceding paragraphs are unusual. In 1924, the total value of metered free water was $197,228.60 and in 1925, $200,072.50, as compared with $214,787.20 in 1926.

The Water Division itself pays for everything it receives. It contributes its share toward other City departments whose services it uses, such as law, civil service, etc. It also pays rent for the use of its quarters in the City Hall. All services of all tax-supported departments are paid. If the Department of Public Service repairs the street or sidewalk after a break or after the installation of a water main or service connection, the Water Division pays the entire cost. If the park lawn or shrubs are disturbed by a water main trench, the entire expense of replacement is borne by the Water Division. The Water Division itself receives no tax money. There is thus seen to be no compensatory services for that which it furnishes. The free services of this Division represent an unqualified diversion of water works funds, a diversion which is not justifiable in logic, in business or in law. The value of this diversion at Cleveland is approximately 5 per cent of the total revenue received.

An ordinance however has just been introduced in the City Council for the purpose of correcting the present policy of free water. If

enacted, this ordinance will place Cleveland in the ranks of the most progressive cities, in that all water furnished will be revenue producing.

DENVER, COLORADO

Direct diversion of water works funds is not permitted in this City and practically no water is furnished free, the city paying for what it uses and in addition paying an annual fire hydrant rental of $22.50 per hydrant. The water works, however, does work for tax supported departments for which it is not paid, such as relaying and lowering water mains and fire hydrants in improvement districts. In 1927 this amounted to over $38,000 which in connection with a small amount for other free services is about 2 per cent of its annual revenue. The water works receives no money from taxes.

LOUISVILLE, KENTUCKY

There is no direct diversion of water works funds in Louisville but water is furnished free to City departments. This includes water for fire protection, parks, public buildings, street sprinkling and public schools. Parochial schools and cemeteries pay for all water used. The water works is operated by a Board appointed by the mayor. No taxes are paid nor does the water works receive any tax money. There is no record of the cost of free service furnished.

MILWAUKEE, WISCONSIN

No diversion of water works funds is permitted in Milwaukee, except that approximately $300,000 is transferred annually to the general fund in lieu of taxes. This $300,000 is approximately 12.5 per cent of the total revenue of the water department. The City pays for all water used for all purposes. The water department does not receive any money from taxes nor does it pay for any service rendered it by tax supported departments such as law, civil service, etc.

PHILADELPHIA, PENNSYLVANIA

The entire income from the water works of this City is placed in the general fund from which appropriations are made for any purpose desired by the City Council. The City does not pay for any water it uses, free water being furnished for public schools, fire protection, parks, public buildings and street sprinkling. Parochial schools and

charitable institutions pay for what water they use at a special rate. The water works does not receive any tax money, but any deficit would be taken out of the general fund.

PITTSBURGH, PENNSYLVANIA

All revenue received from the sale of water in Pittsburgh, Pennsylvania, is placed in the general City fund and the Council may appropriate it for any purpose it sees fit. The City does not pay for any water it uses but water is furnished free to all City departments, to public and parochial schools; for fire protection, parks, public buildings, cemeteries and street sprinkling. Any operating or maintenance deficit is made up from the general fund. The department is operated as though it were tax supported.

PORTLAND, OREGON

Direct diversion of water works funds is not permitted, but indirect diversion is practiced in the furnishing of free water for City buildings, parks, street sprinkling and fire protection. Public and parochial schools and cemeteries pay for all water used. There are no publicly owned cemeteries. The water department receives no money from taxes nor does it pay any taxes directly. It pays a rental charge for City Hall space, but nothing towards its share of the services of Auditor, Treasurer, Attorney, etc. It is considered that part of the free water to the extent of about $75,000 is an offset against taxes. On this assumption the water works funds are being diverted to the extent of approximately $100,000 per year.

ST. LOUIS, MISSOURI

The water works of the City of St. Louis does not permit the direct diversion of water works funds. The department does not furnish free water for public schools, parochial schools or cemeteries. It does, however, furnish it free for fire protection, parks, public buildings and street sprinkling. It pays nothing toward the upkeep of other City departments which render it service. It receives no money from taxes.

SAN FRANCISCO, CALIFORNIA

While the water works of this city is not yet operated as a municipal project, it is proposed that it be controlled by a Public Utilities Commission. If this proposal is accepted in an election to be held

August 28, the use of water works funds will be restricted to water works purposes. The water works will pay for everything it receives and the City will pay for all water and all water works services it may use.

WASHINGTON, D. C.

No direct diversion of water works funds is permitted in Washington, D. C., but indirect diversion is practiced in the form of free water to the extent of about 50 per cent of the annual revenue. Water is furnished free of charge for public schools, parochial schools, fire protection, parks, public buildings, cemeteries and street sprinkling. The water works receives no money from taxes nor does it pay any. Neither does it pay anything for such services as law, treasury, civil service, etc.

CONCLUSIONS

It takes but a simple perusal of the foregoing description of how the water works business is being handled in some of the representative cities of the United States to realize the practical chaos that exists. Diversion in some form or other is practiced almost universally. The entire water works situation, today, is in a state of flux, the older tendency being to divert funds at will, at least in the form of service, while the newer attempts to prevent diversions of any and all kinds. This indeterminate position of publicly owned water works is a detriment to efficient management. It absolutely prevents any just comparison of costs and lays the business open to abuses of many kinds. This is the situation. What is the remedy?

There are but two possible answers to the question. Either publicly owned water works must become tax-supported and tax-maintained municipal departments or they must function absolutely as publicly owned utility enterprises. The first answer is really no answer at all, for a water works whether publicly or privately owned is basically ". . . . a commercial enterprise. It serves a limited number of persons . . . . it is unlike the city hall in that it does not, or may not, give actual or potential service alike to all the people . . . ." (Raymond "The Public and its Utilities"). The water works cannot therefore function as a tax supported department; it is founded on an entirely different principle. The ability to pay taxes and the desire or capacity to use water meet on no common ground.

This leaves no alternative but the operation of the water works as a publicly owned utility and it cannot be so operated unless it functions

as such in its entirety. It not only must *render pay* for every *service* it *receives*, but it *must be paid* for every *service it renders*. This eliminates any gifts of taxation but demands pay for all of the product it furnishes. Raymond in his book "The Public and its Utilities," in the chapter on Taxes, reaches this conclusion:

> **It is concluded, therefore, with respect to a public utility property, that whether the property be under public or private ownership, it should be assessed and pay taxes as other property and should collect these taxes in turn as a cost of service from those whom it serves; and it is concluded further that if in general it be deemed public policy for any reason not to assess a public utility property when owned by the public, it should be equally the public policy to exempt public utility property from taxation when under private ownership.**

He also states in his same book under the title of General Considerations in the chapter on Rate Making for Water Service:

> **It is a cardinal principle, now recognized by courts and commissions, that users of service, either public or private users, should pay for the service in proportion to the costs they entail, and the value of the service rendered; that public service such as fire protection service, sewer flushing, street, park and public building service, should be paid for by the City, and collected in the general tax. It is assumed that such service is for all the people, and that the most equitable way of securing its cost is by assessment in taxes, which may be supposed to distribute the cost somewhat in proportion to the value of the service. . . . . The principle announced in the first sentence . . . . has not been observed generally in the past, and is not observed generally at the present time, although more and more it is being recognized and applied. In many cities owning their own plants, and in some in which the plant is under private ownership, public service is free. This is held to be unfair and of doubtful legality, since it imposes on the private consumers a charge that is properly a public expense chargeable to all tax payers. The free service is the enforced gift of the private consumers.**

This last sentence contains the crux of the entire situation. The fallacy of "free water" is based not on the *principle of justice* but embodies the *doctrine of force*. Embodying this doctrine, it contains the seed of elemental destruction. Either *free water must be eliminated from water works practice or efficient water works management must go down in failure, with its corresponding effect upon municipal government.*

NEW MISSOURI RIVER WATER WORKS OF SAINT LOUIS[1]

By Leonard A. Day[2]

The new water works of the City of St. Louis is located at Howard Bend on the Missouri River about 13 miles west of the city limits. The Chain of Rocks station on the Mississippi River, which is the sole supply at present, might have been enlarged, but the cost would have been but slightly less than the cost of the new plant. The addition of the new plant gives the city two independent sources of supply either of which will furnish enough water to tide over an emergency. Moreover, as shown in figure 1, the new source of supply is closer to the future center of distribution. It is expected that St. Louis County including the suburbs on the western boundary of the city will ultimately be incorporated with St. Louis and supplied with water from our plants.

CAPACITY

The ultimate capacity of the new plant will be 200 m.g.d., but it will not be called upon to deliver more than an average of 55 m.g.d. for a few years to come. The pumping station and coagulant house are being built to accommodate all the equipment necessary for the ultimate capacity. The filter plant is designed for 80 m.g.d. normal capacity and a maximum of 100 m.g.d., but those parts, such as the effluent conduit which will be common to the present plant and the future addition are designed for the ultimate capacity (see fig. 2).

BUILDINGS

The filter plant and coagulant house are of reinforced concrete and the other buildings of steel construction. All buildings are designed in the same style to harmonize. The outside walls are rubble masonry with Indiana cut stone trim. All of the buildings are lined inside with grey enamelled brick. The shade chosen is not glaring to the eye, yet it assures light and cleanliness. In this, as in many other details of the plant, the intention is to provide the best possible

[1] Presented before the San Francisco Convention, June 14, 1928.

[2] Water Commissioner, Department of Public Utilities, St. Louis, Mo.

environment for the employees. There will be an indirect return from the small additional investment in the attitude and efficiency of the personnel. In addition to the effect on the men the impression made on the visiting public must not be forgotten. Only a small percentage of the many visitors are familiar with the problems of engineering. The most expensive and carefully designed equipment installed in poor surroundings will leave the average taxpayer with the feeling that his money is not being handled properly.

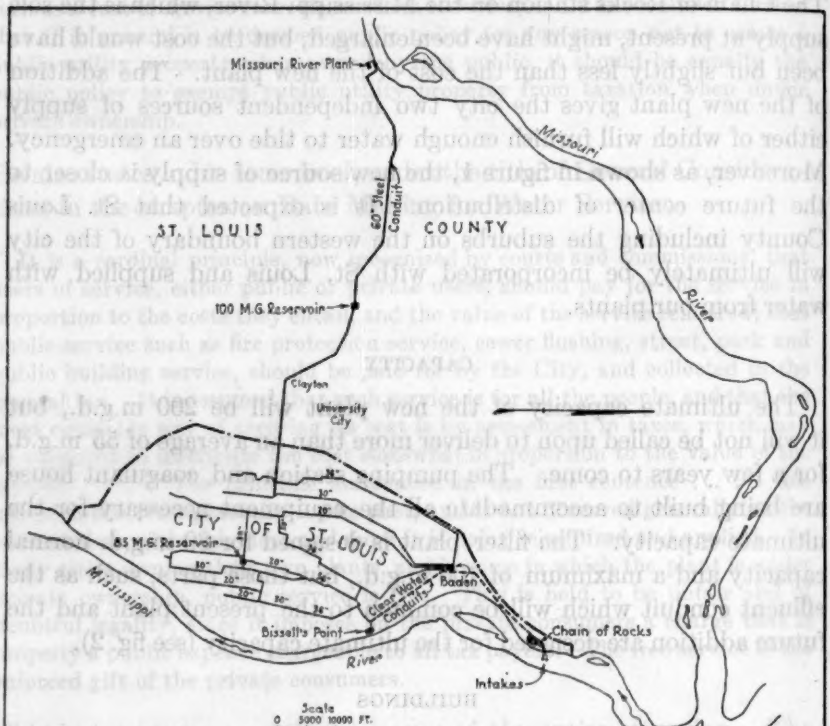

FIG. 1. MAP SHOWING THE ST. LOUIS WATER WORKS SYSTEM

INTAKE

The experience with the two tower intakes at the Chain of Rocks Plant, located near the middle of the river, led to the adoption of a shore intake at the new plant. When sand and gravel are moving by saltation along the bottom of the river at the towers, the tremendous swirling of the water caused by the towers takes these materials into

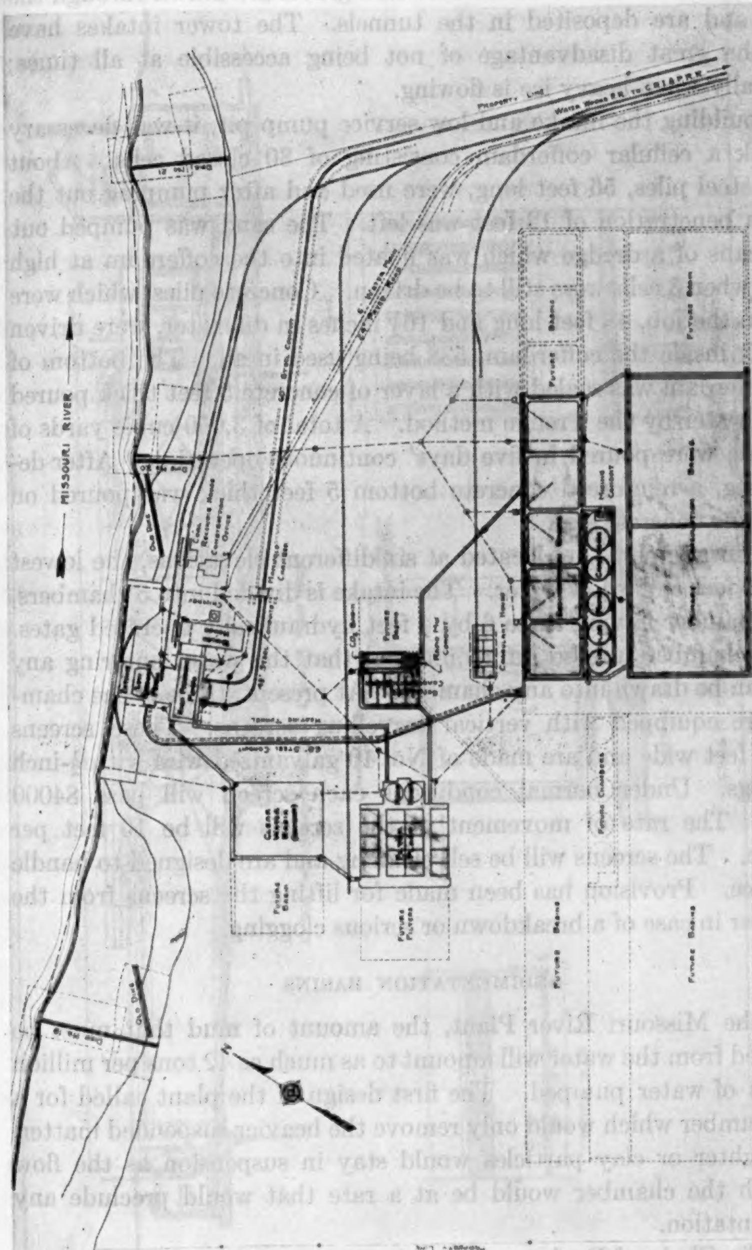

FIG. 2. GENERAL PLAN OF THE MISSOURI RIVER PLANT

suspension and as a result the sand and gravel are drawn through the gates and are deposited in the tunnels. The tower intakes have also the great disadvantage of not being accessible at all times; especially when heavy ice is flowing.

In building the intake and low service pump pit, it was necessary to sink a cellular cofferdam consisting of 30 closed cells. About 1,666 steel piles, 56 feet long, were used and after pumping out the sand a penetration of 12 feet was left. The sand was pumped out by means of a dredge which was floated into the cofferdam at high water when 3 cells were still to be driven. Concrete piles, which were cast on the job, 48 feet long and 16½ inches in diameter, were driven to rock inside the cofferdam, 538 being used in all. The bottom of the cofferdam was sealed with a layer of concrete 5 feet thick poured under water by the Tremie method. A total of 3,050 cubic yards of concrete were poured in five days' continuous operation. After de-watering, a reinforced concrete bottom 5 feet thick was poured on top of the concrete seal.

The intake ports are located at six different elevations, the lowest being 9 feet below low water. The intake is divided into 5 chambers, each chamber having three 6 by 4 feet hydraulically operated gates. These chambers are so interconnected that the water entering any gate can be drawn into any chamber. At present, three of the chambers are equipped with vertical travelling screens. These screens are 10 feet wide and are made of No. 10 galvanized wire with ½-inch openings. Under normal conditions each screen will pass 84000 g.p.m. The rate of movement of the screens will be 10 feet per minute. The screens will be self cleaning and are designed to handle slush ice. Provision has been made for lifting the screens from the chamber in case of a breakdown or serious clogging.

SEDIMENTATION BASINS

At the Missouri River Plant, the amount of mud that must be removed from the water will amount to as much as 42 tons per million gallons of water pumped. The first design of the plant called for a grit chamber which would only remove the heavier suspended matter. The lighter or clay particles would stay in suspension as the flow through the chamber would be at a rate that would preclude any sedimentation.

At the Chain of Rocks, we have more coagulation basins than are absolutely necessary for successful operation so that, if one or two

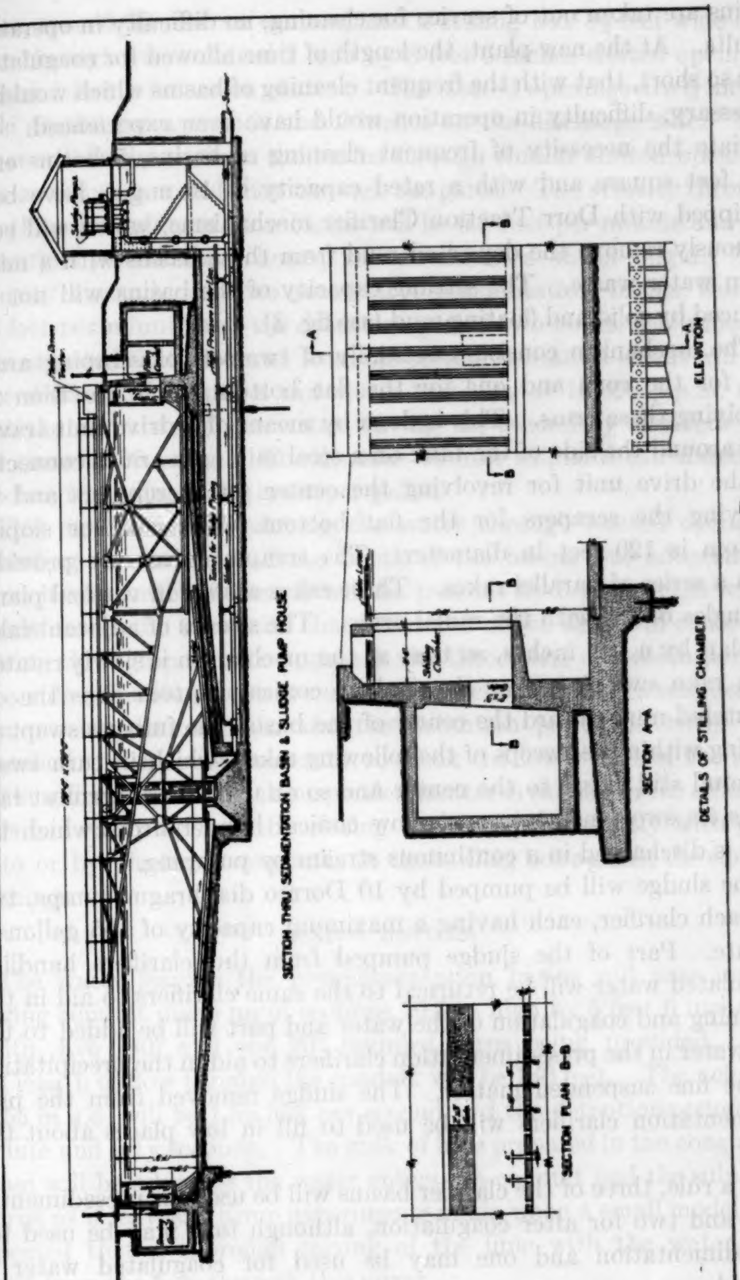

FIG. 3. DETAILS OF SEDIMENTATION BASINS

basins are taken out of service for cleaning, no difficulty in operation results. At the new plant, the length of time allowed for coagulation was so short, that with the frequent cleaning of basins which would be necessary, difficulty in operation would have been experienced. To obviate the necessity of frequent cleaning of basins, 5 basins each 150 feet square and with a rated capacity of 16 m.g.d. have been equipped with Dorr Traction Clarifier mechanisms, which will continuously remove the deposited mud from these basins with a minimum water waste. The settling capacity of the basins will not be reduced by solid and floating mud (see fig. 3).

The mechanism consists essentially of two sets of scraping arms, one for the cone and one for the flat bottom, with provision for revolving these arms. This is done by means of a drive unit travelling around the side of the tank on a steel rail. An arm is connected to the drive unit for revolving the center set of scrapers and for carrying the scrapers for the flat bottom. The cone or sloping bottom is 120 feet in diameter. The scraping arms are provided with a series of parallel rakes. These rakes are set in vertical planes at angles of 45° with the radial arms. The sweeps of adjacent rakes overlap by a few inches, so that as the mechanism is slowly rotated, each rake sweeping over the shallow conical bottom slips the encountered mud toward the center of the basin, the furrows swept up coming within the sweeps of the following rakes, which in turn sweep the mud still closer to the center and so on until the innermost rake drops its sweepings into a shallow conical hopper, from which the mud is discharged in a continuous stream by pumping.

The sludge will be pumped by 10 Dorrco diaphragm pumps, two for each clarifier, each having a maximum capacity of 155 gallons a minute. Part of the sludge pumped from the clarifiers handling coagulated water will be returned to the same clarifiers to aid in the softening and coagulation of the water and part will be added to the raw water in the presedimentation clarifiers to aid in the precipitation of the fine suspended matter. The sludge removed from the presedimentation clarifiers will be used to fill in low places about the plant.

As a rule, three of the clarifier basins will be used for presedimentation, and two for after coagulation, although four may be used for presedimentation and one may be used for coagulated water if desired.

The water will enter each clarifier unit through five 2 by 3 feet

gates, spaced 30 feet on centers, into a stilling box $3\frac{1}{2}$ feet wide and then through one hundred 2 inch by 8 feet 6 inches slotted openings spaced 1 foot 6 inches on centers. The slotted openings are 6 inches wide on the entrance side and 2 inches on the discharge side. The water will be drawn from the basins through similar slotted openings into a stilling box and then through the gates. The velocity through the three presedimentation basins will be 0.8 foot per minute and the detention period three hours, sixteen minutes at 55 m.g.d. The velocity through the two secondary sedimentation basins will be 1.2 feet per minute and the detention period two hours, ten minutes. It is expected that the water from the presedimentation basins will not exceed 500 p.p.m. with a raw water turbidity of 10,000 p.p.m. and that the turbidity of the water leaving the secondary clarifiers will not exceed 200 p.p.m. The amount of iron sulphate calculated to produce this effluent is $\frac{3}{8}$ grain per gallon.

This method of introducing the water through slotted openings extending almost one-half the depth of the basins was adopted because it was believed that it will be possible to distribute the water evenly across the basin and that the depth of the slots will cause the flowing through period to approach the theoretical detention period. As a rule skimming weirs are used on the effluent side of a sedimentation or coagulation basin and the detention period is never approached. It may be necessary to block the lower part of the slots on the effluent side if much suspended matter is carried in the effluent. This can easily be done by closing the slots permanently with concrete or by placing stop-planks in the stilling box against the slotted openings.

MIXING DEVICES

The water leaving the presedimentation basins will pass into a mixing conduit made up of sections 10 feet high by 5 feet 6 inches in width, five 180° and one 90° rounded turns being provided. The full length of flow through the conduit will be 170 feet. The velocity at 55 m.g.d. will be 1.55 feet per second and the detention period one minute and fifty seconds. The milk of lime prepared in the coagulant house will be added as the water enters the conduit and the sulphate of iron as it leaves. From experiments made upon a small model it is expected that a thorough mixing of the lime with the water will result from the flow through this mixer.

The water will pass from the mixing conduit into four circular

mixing or reaction tanks, each 65 feet in diameter. It will be introduced tangentially at the top and be taken off at the center in the bottom. Each unit is designed for a maximum capacity of 16 m.g.d., and at this rate the mean velocity will be about 0.6 foot per second and the detention period will be twenty-six minutes. With four tanks in service the velocity and detention period will be somewhat less when 55 m.g.d. are being pumped. The entrance velocity may be increased by decreasing the size of the entrance conduit. Quite a few similar mixing tanks are in use in the East, the only difference being that the water enters tangentially at the bottom and is taken off at the top side or top center through an overflow.

PRIMARY COAGULATION BASINS

From the circular mixing tanks the water will go through the secondary sedimentation basins already described, and then will pass into two primary coagulation basins each 406 by 330 feet. The basins will be operated in parallel, although it will be possible to operate them in series. The manner of entrance and egress of the water will be the same as in the sedimentation basins, except that the gates will be spaced on 40 feet instead of 30 feet centers. The velocity of the water through the basins at a 55 m.g.d. rate will be 0.4 foot per minute and the detention period will be thirteen hours. It is expected that the water leaving these basins will not exceed 5 p.p.m. The same reasons for providing these basins with the long slotted openings prompted their use in the clarifiers.

COAGULANT HOUSE

All of the chemicals will be prepared in the coagulant house and the solutions will flow by gravity to the mixing conduit. The chemicals; lime, sulphate of iron, and aluminum sulphate will be received in bulk in box cars. These chemicals will be unloaded by means of a pneumatic conveyor and will be drawn into a filter recipient, equipped with gate type locks, located 60 feet from the car (fig. 4). The capacity of the unloading device will be 15 tons per hour. The air discharged from the vacuum pump will be used to transport the chemicals to the storage bins, the maximum distance being 120 feet. A distributor will be provided in each bin to assure the proper distribution of the chemical in the bin.

Pebble lime will be purchased but a crusher will be provided in case pebble lime is not always available. A large freight elevator is also

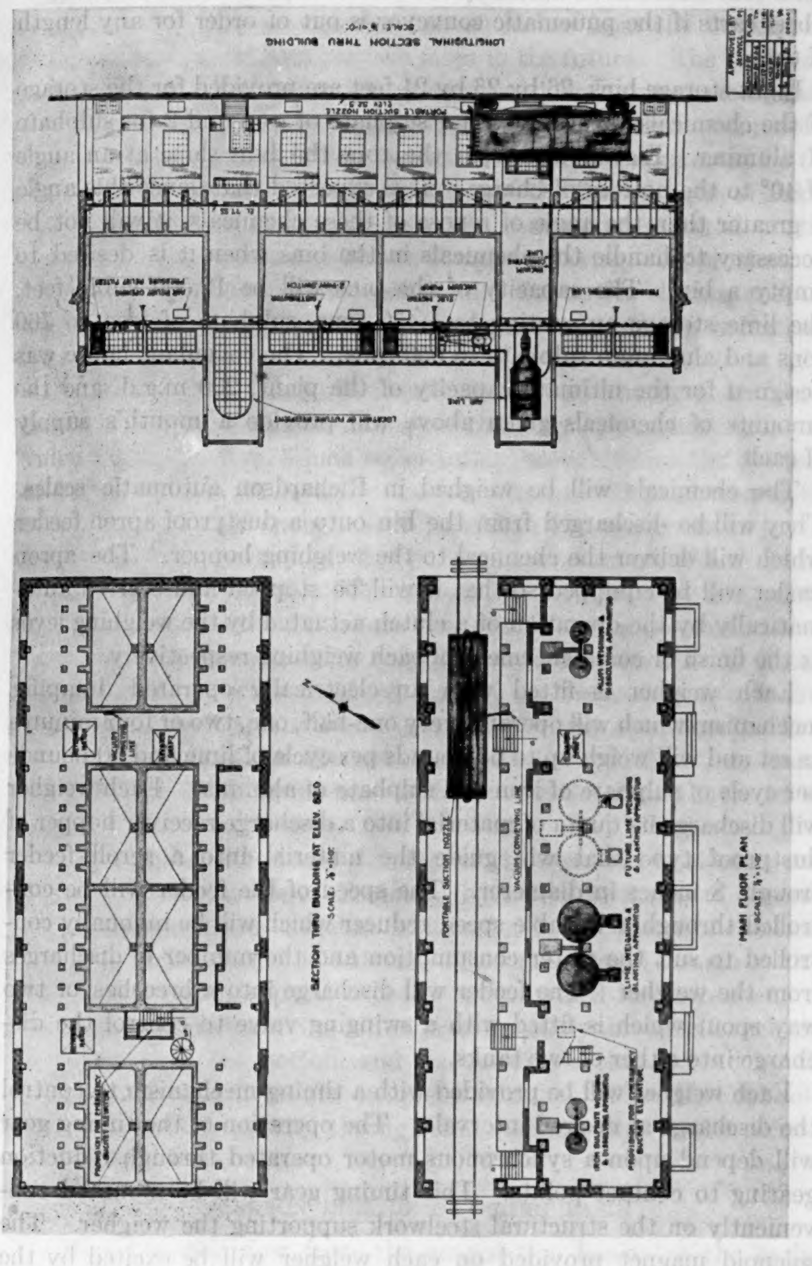

FIG. 4. PLANS AND ELEVATIONS OF COAGULANT HOUSE

provided in case it is necessary to unload the cars of chemicals into wheel carts if the pnuematic conveyor is out of order for any length of time.

Eight storage bins, 26 by 26 by 21 feet are provided for the storage of the chemicals, 4 for lime, 2 for sulphate of iron and 2 for sulphate of alumina. Eleven feet from the top, the bins slope at an angle of 40° to the bottom discharge. It is expected that, since this angle is greater than the angle of repose of these chemicals, it will not be necessary to handle the chemicals in the bins when it is desired to empty a bin. The capacity of the bins will be 12,500 cubic feet, the lime storage amounting to 1,450 tons, sulphate of iron to 760 tons and aluminum sulphate to 650 tons. The coagulant house was designed for the ultimate capacity of the plant, 200 m.g.d. and the amounts of chemicals given above will provide a month's supply of each.

The chemicals will be weighed in Richardson automatic scales. They will be discharged from the bin onto a dustproof apron feeder which will deliver the chemical to the weighing hopper. The apron feeder will be equipped so that it will be stopped and started automatically by the operation of a clutch actuated by the weighing lever at the finish or commencement of each weighing respectively.

Each weigher is fitted with an electrically operated dumping mechanism which will operate every one-half, one, two or four minutes as set and will weigh up to 65 pounds per cycle of lime and 50 pounds per cycle of sulphate of iron and sulphate of alumina. Each weigher will discharge its quota of material into a discharge receiver hopper of dustproof type that will guide the material into a scroll feeder trough, 8 inches in diameter. The speed of the feeder will be controlled through a variable speed reducer which will be manually controlled to suit the water consumption and the number of discharges from the weigher. The feeder will discharge into a breeches or two way spout which is fitted with a swinging valve to control the discharge into either of two tanks.

Each weigher will be provided with a timing mechanism to control the discharge at desired intervals. The operation of the timing gear will depend upon a synchronous motor operated through reduction gearing to contact points. This timing gear will be mounted conveniently on the structural steelwork supporting the weigher. The solenoid magnet provided on each weigher will be excited by the timing gear at the interval at which delivery of desired charges of material is required.

Two lime slaking tanks each 9 feet 4 inches in diameter and 3 feet 4 inches deep with an overflow at 30 inches from the bottom are provided with provisions for two more in the future. The tanks are equipped with rigid shear plows supported on a monel metal shaft driven by a motor through reduction gearing. This shaft will revolve 16.4 times per minute. The vertical drive shaft is supported by top and bottom bearings. The plows will keep the fine particles of slaked lime in suspension and will turn over the unslaked material on the bottom of the tank and so ensure complete slaking. Approximately 4½ pounds of water are used per pound of lime for slaking and the minimum slaking period will be thirty minutes, slaking being continuous.

The hot milk of lime will overflow from the slaking tank into a heater 2 feet 8½ inches in diameter and 8 feet 8½ inches high, provided with forty-five 3-inch boiler tubes through which the hot milk of lime will flow. The water used in slaking will pass around the tubes and pick up enough heat to enable the temperature in the slaking tank to be kept at 200°F., a temperature at which slaking takes place very rapidly. The heater has a capacity of 500 gallons and is not operated under pressure so that it will be possible to clean the boiler tubes while it is in service. The bottom of the heater tank is equipped with revolving paddles as the tank will over-flow through a pipe separate from the tank and at an elevation but little below the elevation of the water in the slaking tank. Two heater tanks are provided at present with provisions for two more in the future.

The sulphate of iron and alumina will be dissolved in circular steel tanks, 5 feet 2½ inches in diameter, lined with 2¼ inches of concrete and with an overflow 4 inches in diameter in the center of the tank, 2 feet 10 inches from the bottom. Two tanks large enough to take care of the ultimate plant capacity are provided for each chemical. The water used in dissolving will enter tangentially through a 3-inch pipe 10 inches from the bottom and the swirling action created by the entering water will ensure complete solution. The chemical solutions will flow by gravity through acid resisting pipe to the point of application.

CARBON DIOXIDE CHARGING BASIN

The water will flow from the coagulation basins to the carbon dioxide charging basin, 110 feet long, 41 feet wide and 18 feet deep,

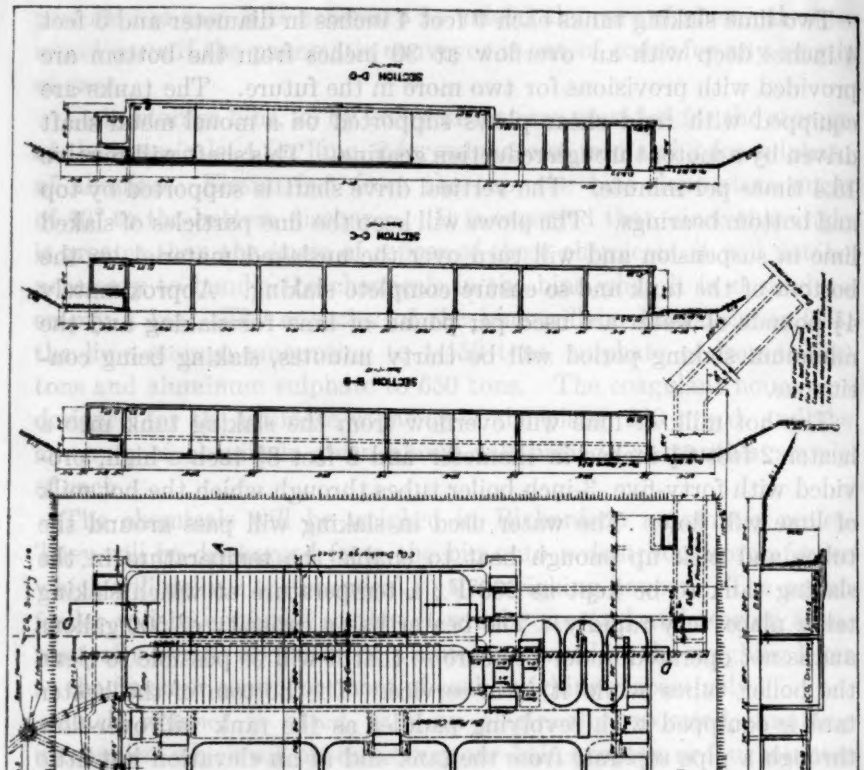

FIG. 5. SECTION OF COAGULATING BASINS SHOWING CO_2 PIPING

with a baffle running through the basin. The carbon dioxide will be introduced into the water through two headers fitted with laterals which will ensure equal distribution of the carbon dioxide through the water (fig. 5). The carbon dioxide will be obtained from the flue gases and will pass through a wet and dry scrubber before being sent to the basin. The scrubber is located in the base of the stack.

The average normal carbonate of the water to be treated will be approximately 44 p.p.m. and this will be reduced by carbon dioxide so that upon the addition of aluminum sulphate the normal carbonate alkalinity will be reduced to a point where only a faint pink color will be obtained when phenolphthalein is added to the water.

SECONDARY COAGULATION BASIN

From the carbon dioxide chamber, the water will flow through a secondary rapid mixing conduit similar to the one already described except that the length of travel and velocity will be slightly less. The aluminum sulphate will be added as the water enters this conduit. From the mixing conduit, the water will flow through the secondary coagulation basin 90 feet long, 159 feet wide, with 7 baffles 70 feet long making channels 19 feet wide. The velocity at 55 m.g.d. with the channels operated in series will be 0.37 foot per second and the detention period thirty-two minutes. The aluminum sulphate will be thoroughly mixed with the water in the mixing conduit and the slower flow with the gentle mixing accomplished by the around the end bafflles for over half-hour should yield maximum results. The basin is so arranged that the channels may be used in parallel or series or may be by-passed. No sedimentation will take place in this basin so that water leaving the coagulation basins must contain but little suspended matter and a minimum of sulphate of alumina may be used. The reduction in pH produced by the carbon dioxide will decrease the amount of residual alumina and better floc formation will result from smaller amounts of aluminum sulphate.

The water from the secondary coagulation basin will flow to the filter plant. There will be 20 filters, each 50 by 28 feet and each of 4 m.g.d. capacity, based on the standard of 2 gallons per square foot per minute. There will be two main gutters, one on each side of the filter. The lateral gutters were precast in an inverted position, two of the precast gutters being joined and supported at the center line by a concrete vertical tie, 6 inches thick. The outflow ends of the gutters rest in a notch provided in the walls of the main gutters.

The lateral gutters, 1 foot $3\frac{7}{8}$ inches deep and 1 foot 10 inches wide are placed on 5 foot $6\frac{3}{4}$ inches centers, 9 to a filter. The top of the gutter will have a rounded edge and will be 24 inches above the top of the sand.

The underdrain consists of a flanged pipe of varying diameter and sloping bottom, placed below the center of the filter and 50 feet in length. This pipe is made up of the following sections:

NUMBER	LENGTH		DIAMETER				SLOPE OF BOTTOM
			From		To		
	feet	*inches*	*feet*	*inches*	*feet*	*inches*	*inches per foot*
1	12	$9\frac{1}{2}$	3	0	2	9	0.25
2	12	0	2	9	2	4	0.42
3	12	0	2	4	1	10	0.50
4	10	0	1	10	1	2	0.80
5	4	0	1	2	0	8	1.50

The underdrain pipes were made with bell outlets at the top in which were placed 5-inch tees with 4-inch flanged outlets. The tees were leaded in place and the cast iron laterals were connected to the tees. The laterals on each side of the tees are made up of 4 feet 1 inch of 4-inch pipe, 3 feet 11 inches of $3\frac{1}{2}$-inch and 5 feet of 3-inch pipe welded together by Tobin bronze welds. The end of the 3-inch pipe is capped. At the end and on each side of the welds, 3-inch concrete supports are provided for the laterals. The pipe laterals are drilled with two rows of holes, the holes making an angle of $22\frac{1}{2}$ degrees with the vertical. They are placed 3.36 inches apart and are staggered in the rows, making the distance between holes, 6.72 inches in each row. Brass eyelets $\frac{1}{32}$ inch thick with a hole $\frac{3}{8}$-inch in diameter were forced into the holes and peaned over inside and outside to make a smooth surface. The ends of the laterals and the cast iron tees are also provided with holes. This system of varying size pipe in both the underdrain and laterals was adopted to ensure equal distribution of the wash water and from tests made on this layout, our expectations should be realized.

Above the laterals will be 18 inches of Merrimac River gravel of the following sizes—6 inches passing a $2\frac{1}{2}$ inch round hole and retained on screen with a $1\frac{1}{2}$ inch hole; 6 inches passing a $1\frac{1}{2}$ inch and retained on $\frac{3}{4}$ inch screen; 4 inches passing a $\frac{3}{4}$ inch and retained on $\frac{3}{8}$ inch screen; 2 inch passing $\frac{3}{8}$ inch and retained on $\frac{3}{16}$ inch screen. Above

the gravel will be 20 inches of Ottawa sand, dried and graded before being placed in the filters. The effective size will be 0.42 to 0.47 mm. and the uniformity coefficient 1.60.

The height of the water over the sand will be approximately 8 feet so that the filters will rarely operate under negative head, and so decrease the trouble experienced from the packing and breaking of the filter bed due to filtering at considerable negative head. The filters will operate at a uniform rate which will be possible because of the large storage at Stacy Park, 100,000,000 gallons.

The chemical laboratory and offices will be located in the head house. The Wallace and Tiernan chlorine machines will also be located in the head house. The chlorine cylinders will stand on chloro-scales which will record the amount of chlorine being used.

The filters will be equipped with a device that will permit the opening of the controller valve to any desired rate in any time up to one hour. From a great many experiments made at the Chain of Rocks, we have found that by this means the amount of turbid water passing the filter after washing will be considerably reduced.

There are two wash water tanks each 50 feet in diameter and with a working depth of 6 feet 6½ inches and each with a capacity of 97,000 gallons. There are three centrifugal wash water pumps direct connected to hydraulic turbines. The capacity of each pump will be 5,000 gallons per minute, with a pressure of 125 pounds at the turbine and with a lift of 35 feet. They will cut in automatically when there is a drop in the head of the water in the tanks.

The controllers were manufactured by the Builders Iron Foundry and the operating tables by F. B. Leopold. Each operating table will be equipped with 7 control levers, 2 for the influent, 2 for sewer outlets, 1 for effluent, 1 for wash water and 1 for filtered waste.

MECHANICAL EQUIPMENT

The mechanical equipment at this plant serves the following purposes:

1. Pumping raw river water from the intake to the primary coagulation basins.

2. Pumping clarified water from the clear water basin to the Strattman Hill reservoir.

3. Furnishing electrical energy for auxiliary equipment and lighting for the entire plant.

4. Furnishing steam for heating and process work for the entire plant.

For convenience, the equipment may be grouped in three structures, namely: (*a*) the boiler house; (*b*) the high pressure building, and (*c*) the low pressure building.

THE BOILER HOUSE

The boiler house is 180 feet long, 60 feet wide, and 80 feet high overall. There are three floor levels as shown in figure 6. The lower or ground floor, elevation 45.0, is separated lengthwise by the ash tunnel. The remaining space is used for the machine shop, blacksmith shop, wash rooms, and store rooms. The operating floor is at elevation 61.5, and the preheater and fans are located on the upper floor at elevation 101.5.

Coal handling

The coal, delivered in hopper bottom cars, enters the unloading room of the coal receiving house, about 200 feet from the boiler house. The coal is emptied into a 14 by 18 feet cast-iron track hopper. A cross conveyor elevates the coarse coal from the opening at the bottom of this hopper to the motor driven ring type crusher which reduces the coal to the $\frac{3}{4}$-inch size necessary for the stokers. The crusher may be by-passed if necessary. The fine coal is elevated by an inclined belt conveyor to the top floor of the boiler house. A horizontal belt conveyor with a mechanically operated tripper distributes the coal in the bunker. The crusher and cross conveyor have a capacity of 100 tons per hour and the 18 inch wide belts have a capacity of 50 tons per hour. The pulleys and idlers on the conveyors are large enough to take a wider belt which will handle the ultimate capacity of 100 tons per hour.

This coal handling machinery is motor driven and the units are electrically interlocked to prevent coal from piling up at any point should a conveyor be accidentally shut down.

A coal bunker of riveted steel plate construction, parabolic in cross section, is suspended from heavy steel girders in front of and above the boilers. The space above the bunker is enclosed by a steel partition which prevents the dispersal of dust over other parts of the boiler house. The bunker has a capacity of 900 tons.

Two electrically propelled weigh lorries, each holding about 2000 pounds run on tracks under the bunker. Each lorry is equipped

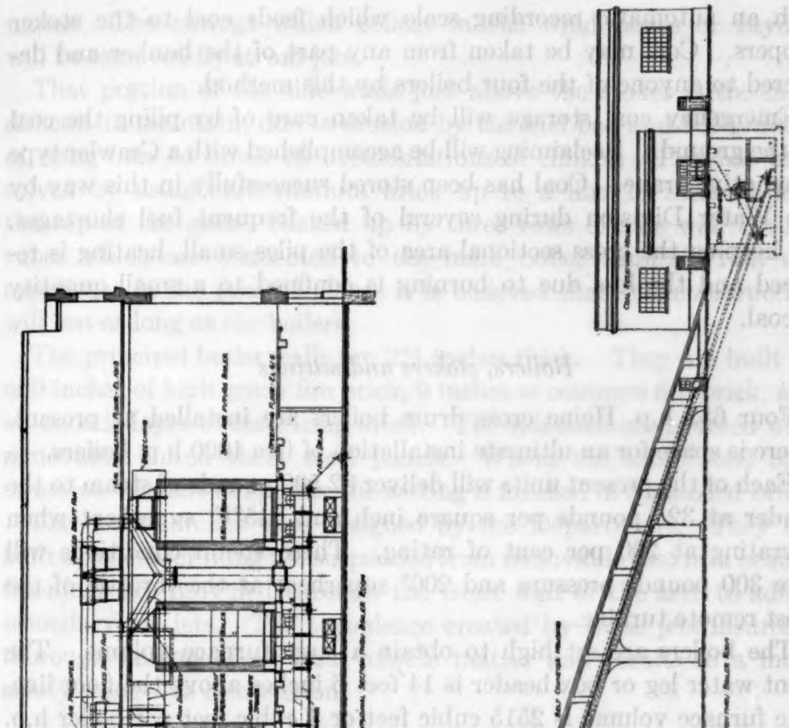

FIG. 6. SECTION THROUGH BOILER HOUSE AND COAL RECEIVING HOUSE

with an automatic recording scale which feeds coal to the stoker hoppers. Coal may be taken from any part of the bunker and delivered to anyone of the four boilers by this method.

Emergency coal storage will be taken care of by piling the coal on the ground. Reclaiming will be accomplished with a Crawler type locomotive crane. Coal has been stored successfully in this way by the Water Division during several of the frequent fuel shortages. By keeping the cross sectional area of the piles small, heating is reduced and the loss due to burning is confined to a small quantity of coal.

Boilers, stokers and settings

Four 652 h.p. Heine cross drum boilers are installed at present. There is space for an ultimate installation of five 1000 h.p. boilers.

Each of the present units will deliver 32,500 pounds of steam to the header at 325 pounds per square inch and 245°F. superheat when operating at 200 per cent of rating. These steam conditions will give 300 pounds pressure and 200° superheat at the throttle of the most remote turbine.

The boilers are set high to obtain a large furnace volume. The front water leg or box header is 14 feet 6 inches above the floor line. The furnace volume is 2515 cubic feet or 4 cubic feet per boiler h.p.

The baffling is a combination of horizontal and vertical baffle walls. The lower two rows of tubes are fully exposed to the radiant heat of the fuel bed and furnace walls. The horizontal baffle is built up of T tile resting on the second row of tubes. The vertical walls are monolithic and are cast in place around the tubes.

Two types of superheaters are used. Steam from the main boiler drum first passes through a convection superheater mounted above the main tube bank, and attains its final temperature in a radiant heat superheater built into the rear wall of the boiler setting. This combination of two types of elements reduces the initial cost and assures a more constant final steam temperature.

The stokers are of the forced draft chain grate type, adapted for preheated air. The chain grate stoker is well adapted to the high ash, low heat value Illinois coals available in our locality. The forced draft type is more flexible and will give slightly higher efficiencies than the natural draft stoker. The grate surface of each stoker is 162 square feet or about 1 square foot to 40 square feet of boiler heating surface. Each stoker is driven by a variable speed

motor. The siftings which collect in the wind boxes or tuyeres will be removed by steam jets.

That portion of the side walls just above the stoker is the most difficult to maintain, due to erosion by the fuel bed and the practise of using bars to break off accumulations of clinker. This has been solved by using carborundum brick up to a line 18 inches above the top of the grate, backed up by three rows of side wall cooling tubes which are connected to the main boiler drum. From our experience in the present plants it is believed that this construction will last as long as the boilers.

The principal boiler walls are 22½ inches thick. They are built up of 9 inches of high grade fire brick, 9 inches of common fire brick, and an outside layer of insulating brick. The sidewalls are covered with removable bolted sheet steel panels. Where the sheet steel construction was not adaptable the setting is finished in enamelled brick.

The stoker arches were designed by the Department. They are built up of center hung tile suspended from removable cast iron beams. Openings are provided through the front wall of the arch to admit secondary air jets. The turbulence created by these jets insures a thorough mixing of air and volatile matter and results in a more nearly smokeless combustion.

Ash handling

The ash falling over the rear stoker sprocket drops into a fire brick lined ashpit from which it will be regularly removed by hand. The ash will be pulled into the drag conveyor which runs lengthwise in the ash tunnel and will be deposited in a pit at the end of this tunnel. A bucket elevator will hoist the ash and store it in a reinforced concrete ash hopper set above the tracks at the end of the boiler house.

Fans and preheaters

The upper floor of the boiler house, at elevation 101.5, supports the fans, air preheaters and air ducts.

There are four motor driven forced draft fans, each capable of supplying 24,000 cubic feet of free air (110°F.) per minute against a static head of 3 inches. The duct system is so arranged that air at normal temperature, or preheated air, may be supplied to any boiler by any of these fans.

Preheaters of the Ljungstrom type are installed on two boilers.

The other two boilers will be similarly equipped if the present installation presents no operating difficulties. The heat transfer device is a heavy steel rotor filled with crimped and plain steel plates which form a large number of gas or air passages. This rotor revolved from the outside, receives heat from the flue gas on one side of the cylindrical housing and gives up this heat to the air which is forced through the other side. The air temperature will be raised about 300°F. and the flue gas temperature will be decreased by about the same amount. The expected fuel saving with this device is about 10 per cent.

Induced draft fans are used on the two boilers which are equipped with preheaters to take care of the increased draft loss. All of the flue gas is finally led into a 9 by 7 feet breeching and into the chimney. The chimney is 275 feet high above the ground and about 13 feet in diameter inside.

Control

The gauges and instruments for each boiler will be grouped on a control board in full view of the fireman on watch. On this panel will be mounted:

1. Steam gauges showing pressure in the drum and in the header.
2. Superheat thermometers, indicating the steam temperature after the convection superheater and before entering the header.
3. A steam flow, air flow meter showing the load on the boiler and indicating the proper air supply.
4. Push button controls for starting and stopping the fans.
5. Stoker speed control.

An automatic combustion control system will regulate draft, damper settings, and stoker speed to suit the load. Automatic feed water regulators will maintain the proper water level in the boiler. In general, the most modern methods of control and operation will be followed to reduce labor, to increase efficiency, and to promote safety.

Piping

The piping for high pressure steam and boiler feed water is an important part of a high pressure plant. The high temperature especially calls for great precaution in design, since it increases expansion and has the effect of lowering the strength of practically all metals. All steam piping is of extra strong dimensions. The

larger sizes are double random length seamless drawn steel tubing. Since it is practically impossible to take apart screwed joints, once they have been in service under high pressure and temperature, all of the valves and all fittings 1 inch and larger are flanged. The larger fittings and valve bodies are of chrome-nickel cast steel. The joints on pipe 2½ inches and larger are made by the Van Stone process, i.e. the pipe is flared out and upset over the flange. The joint is thus made, not between the flanges which are loose on the pipe, but between the ends of the pipe. Chrome nickel steel studs, threaded throughout their length are used for bolting on all high pressure lines.

The main steam header in the plant is a loop which is carried through the entire plant and closed in the low pressure pit and in the boiler house. The turbines in the high pressure pit are fed by a separate header each end of which connects to a leg of the main loop.

HIGH PRESSURE BUILDING

The high and low pressure buildings are combined in plan to form a T-shaped structure. Galleries are provided on the edges of both pits, and in the high pressure building a bridge spanning the pit gives direct access from the main entrance and engineers office to the low pressure building.

A twenty ton electric crane is installed in each building.

A concrete suction conduit 8 feet wide by 13 feet high inside delivers clear water from the clear water basins to the high pressure pit. This conduit was poured integral with the pit.

High head pumps

The pit is large enough to accommodate six 40 m.g.d. normal rating turbine driven pumps, two of which are installed at present. These units have a maximum capacity of 60 m.g.d. each against a head of 360 feet. Two single stage pumps in series are arranged one behind the other and driven by a common shaft from the same gear. This gear is driven by two pinions, one on each side. One pinion is driven by the high pressure element of a compound steam turbine, the other pinion by the low pressure element. The double pinion drive reduces thrust and wear, and the separation of the turbine into two distinct casings offers slightly better economies in steam consumption. A bleeder connection at the ninth stage permits the extraction of steam for heating feed water or buildings.

A power plant condenser with steam jet air ejector and dual drive condensate pump is installed on each unit. The circulating water pump is driven from the main pump shaft.

The horsepower of each unit running at full load is about 6000. The duty, although no higher than that of triple expansion engines operating at lower steam pressure, is high for a turbine driven centrifugal pump. The final tests should show duties of more than 170 feet pounds per B.t.u.

A new type of automatic check valve which has worked successfully in Chicago and Detroit is installed in the discharge line of each pump. This valve is in effect a huge corporation cock turned by a hydraulic cylinder. The pilot valve which admits water to open or close the check is actuated by pitot tubes in the main valve body. It is claimed that water hammer is eliminated because the valve closes before the flow of water is reversed. Practically all other checks depend upon stopping or actual reversal of the flow for closing.

All of the large suction and discharge valves in this pit, and also in the low pressure pit, are hydraulic cylinder operated.

A simple manifold built up of steel fittings is all that is required at present. The two 48-inch steel conduits leading the pump discharges to the manifold will be connected here to the single 60-inch steel conduit which supplies the reservoir.

In the large open space between the high pressure and low pressure pits, room is provided on one side for unloading machinery and material directly from railroad cars, and on the other side for the electric generating units and the main switchboard.

Two of the generating units are driven by extraction or bleeder steam turbines. Each unit has a capacity of 300 kilowatts at 80 per cent power factor. At full load it will be possible to bleed 9000 pounds of steam at 50 pounds pressure. This will be used for process heating in the coagulant house and for the evaporators in the low pressure pit. Any excess not used for these purposes may be used in the heating system during the winter. The bleeder turbine gives the flexibility required for maintaining a heat balance and results in better overall economy because the extraction steam has been allowed to do work in the turbine. The condensers and auxiliary equipment are contained in a room below the units.

Considering the number of important auxiliaries which are motor driven, it is advisable to have a source of power which will be altogether independent of other equipment in the plant. For this reason

a 90 kilowatt generator matching the others in electrical characteristics and driven by a 6 cylinder gasoline engine is mounted alongside of the steam turbine driven units. In emergencies this unit will supply power to auxiliaries and furnish light.

The main switchboard, just behind the generators distributes 3 phase alternating current at 440 volts to the secondary distribution panels. All motors, excepting the smallest, operate at this voltage. Single phase 115 volt current for lighting is supplied by transformers at each secondary distribution point.

A duplicate buss bar on the main switchboard and double throw breakers on each circuit will allow the gasoline engine driven generator to take any part of the load without paralleling the generators.

LOW PRESSURE PIT

The low pressure pit in plan is a circle 90 feet in diameter, flattened along the wall of the intake chambers. The pit floor is 45 feet below the operating floor (fig. 7).

Three turbine driven single stage centrifugal pumps are installed. The largest has a capacity of 80 to 120 m.g.d. and the two small units are 40 to 60 m.g.d. each. There is space for two additional units of the larger size. Due to the small horsepower involved (about 500 h.p. for the small units and 1000 h.p. for the other) it was not practical to use a compound turbine. In fact the enormous weight of the driven gear almost solves the problems of thrust. The gear ratio of the largest unit is 26.57 to 1.00 with a driven gear 122 inches in diameter. This is the largest gear ever used for land service.

It was in the pumping of raw water containing sand and other foreign matter injurious to reciprocating pumps that the steam turbine driven centrifugal pump first proved its reliability. Three of these units have been in operation at our present low head plant, the Chain of Rocks Station for years, two 40 m.g.d. units since 1912.

The low pressure pit contains all of the equipment for purifying, heating, and pumping feed water. Two deaerating heaters with large water storage compartments are located on the operating floor. All drains, condensate, returns, and makeup water are piped to these heaters. Steam is supplied from the exhaust of auxiliary turbines or from the bleeder connections on the high head units. The feed water, free of oxygen and heated to 212° is pumped to the boilers by one of three centrifugal boiler feed pumps. The two pumps which will be generally used are motor driven and a third is steam turbine

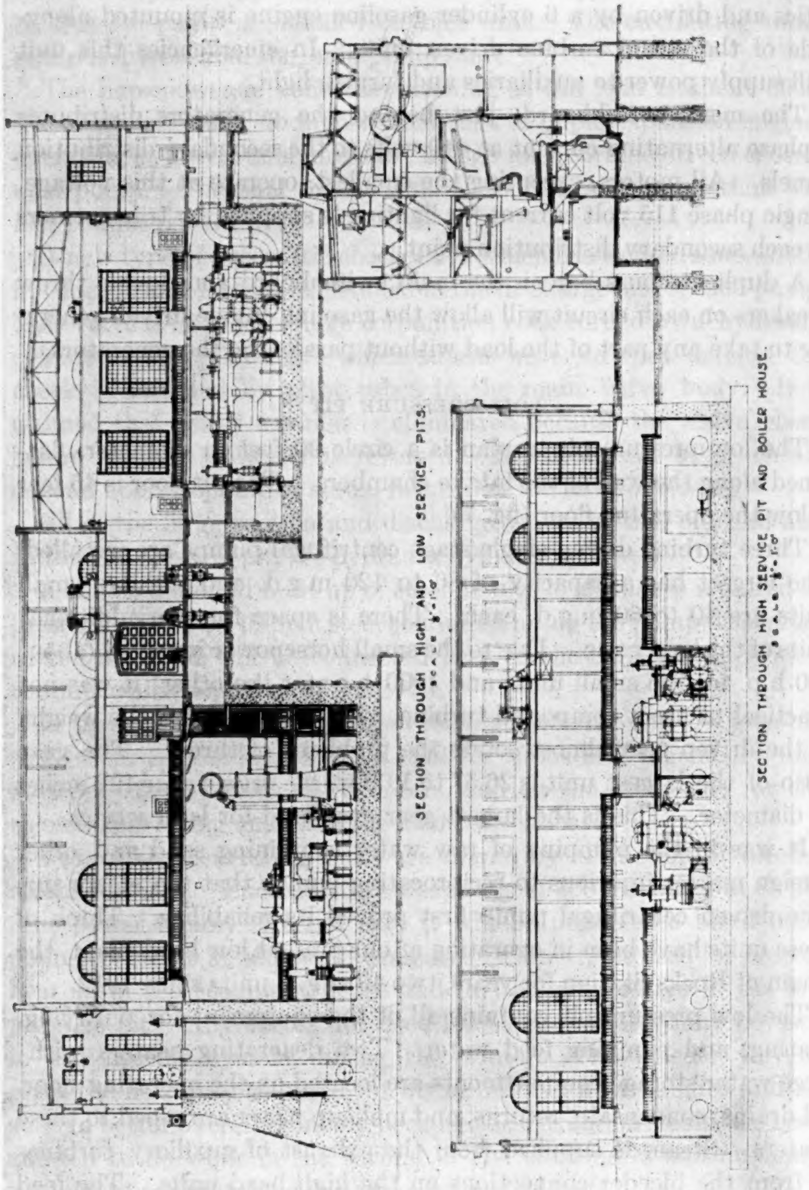

Fig. 7. Section Through High and Low Pressure Pits and Buildings

driven. Each pump has a capacity of 200 g.p.m. against a head of 400 pounds per square inch.

All of the returns to the heater are practically pure distilled water, free of oil. The makeup, however, added without treatment will add about 16 grains of solids per gallon of makeup added. This would be sufficient to build up an appreciable concentration in the boilers in time. Hard scale formation can be almost entirely prevented by treating the makeup in a Zeolite softener, but the total solids will remain about the same. As long as there are dissolved solids in the water, even though no hard scale is formed, there is the possibility of carrying this solid matter in the steam to the turbines in the form of fine, dry dust. At the high velocities used the wear on turbine blading, nozzles, and valves due to this suspended matter may be very rapid.

The makeup water in this plant is first treated in a Zeolite softener. This preliminary treatment costs very little and will simplify the cleaning of the evaporators. If the evaporator is ever taken out of service, the Zeolite softened water can be fed directly to the boiler without causing scale.

The evaporators are of the single effect, high heat level type. Water from the softeners is heated and deaerated in a small open heater using exhaust steam and is then pumped into the evaporator shell. The heat for the submerged evaporating coils is normally supplied by steam at 50 pounds pressure extracted from the generating units, but live steam reduced by an orifice plate may be used if necessary. The vapor from the evaporator shell and the condensate from the coils are trapped to a high pressure condenser, which uses boiler feed water at full pressure (400 pounds) as a cooling medium. The feed water will be raised from 212° to about 265°F. The distilled water will be discharged into the heater under the control of a float valve.

A good heat balance in a steam power plant is obtained when there is no evident waste such as that due to the escape of steam, drains, or heating returns; or the use of live steam reduced for heating and process work. The most carefully made preliminary analysis is not in itself sufficient. There must be flexibility to enable adjustments to be made for load changes and changes in the distribution of steam. This flexibility is obtained by using auxiliaries driven by either of two units such as the steam and hydraulic turbine driven condensate pumps, and by using separate motor and steam

turbine driven units such as the boiler feed pumps. In addition, bled steam at about 5 pounds pressure from the high head pumping units and bled steam at 50 pounds pressure from the generating units can be varied from nothing up to the limit of the machine.

Good operating results are expected of this station. The steam conditions are high enough to result in high duties for the main units, yet the extremes of temperature which cause trouble with piping, fittings, and valves have not been reached. It is believed that by using feed water of practically zero hardness, wear due to erosion will be eliminated and high boiler efficiencies will be maintained.

STEEL CONDUIT AND RESERVOIR

The discharge from each pump is led through a 48 inch riveted steel line to a simple manifold built up of cast steel fittings and hydraulically operated cast steel gate valves. A venturi meter is installed in each discharge line. A single conduit 8.9 miles long connects the manifold with the reservoir. The conduit was to be made of 60-inch hammerweld pipe according to the contract, but there was difficulty in obtaining this material, and practically all of the line is built 62-inch steel riveted pipe. The increase in diameter easily offsets the increased friction due to rivets. The thickness of the line varies from $\frac{9}{16}$-inch at the plant, where the maximum pressure will be 150 pounds, to $\frac{3}{8}$-inch at the reservoir where the pressure will not exceed 20 pounds.

The reinforced concrete reservoir 800 feet long and 600 feet wide, with a depth of water of 30 feet will hold 100 million gallons. It is entirely covered to prevent contamination. The reservoir is located at the highest point in St. Louis County. Water will flow by gravity through a steel line similar to the one described into the system in the western half of the city. The reservoir is about 6 miles from the city limits.

CONCLUSION

This entire plant has been designed and the construction is being supervised by Water Division Engineers. There has been no hesitancy in accepting modern methods and equipment, but the size of the plant and the conditions of operation were kept in mind throughout.

WATER TREATMENT TO PREVENT EMBRITTLEMENT[1]

By Frederick G. Straub[2]

The subject of Embrittlement in Steam Boilers is of paramount importance to people interested in treating water to be used in steam boilers. Cracks in the highly stressed portions of steam boilers, have been causing so much damage in large power plants, with enormous financial outlays for repairs or replacement, that it is necessary to take cognizance of the types of water and water treatment which bring about the trouble and to apply timely methods of counteracting it.

Embrittlement trouble[3] is found usually in the riveted areas of steam boilers. The seams leak and cannot be made tight, rivet heads often crack off, and the plates crack from rivet hole to rivet hole. The boiler often reaches a condition which is very dangerous to the operators before the trouble is detected. Figure 1 shows a picture of a boiler which exploded due to this type of cracking.

Figures 2 and 3 show plates which have been found cracked and illustrate the kind of cracks which characterize this type of cracking. The cracks start on the inside of the seams and cannot be detected by ordinary inspection. Consequently this cracking usually proceeds until the boiler is beyond repair before it is detected.

The time for this cracking to take place varies, but it has been found in boilers as soon as fifteen months after installation. This illustrates the fact that timely prevention of this trouble is necessary and water treatment to prevent it, should be considered as early as possible.

[1] Presented before the Boiler Feed Water Studies Session, the San Francisco Convention, June 12, 1928. Part of research work being conducted at the Engineering Experiment Station, University of Illinois. Released by authority of Dean M. S. Ketchum, Director of the Engineering Experiment Station.

[2] Special Research Assistant in Chemical Engineering, University of Illinois, Urbana, Ill.

[3] Bulletins 155 and 177 of the Engineering Experiment Station, University of Illinois, describe embrittlement in detail.

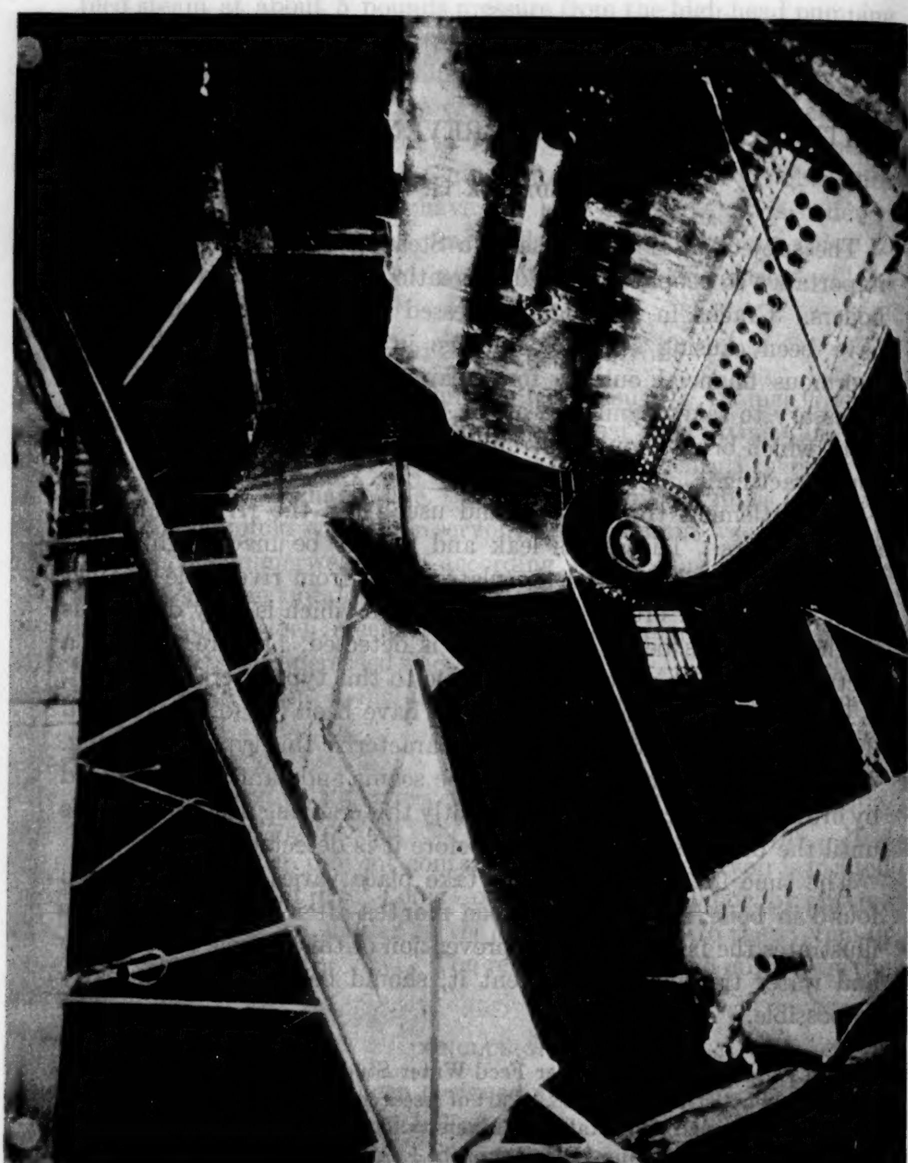

FIG. 1. BOILER EXPLOSION WHICH RESULTED FROM EMBRITTLEMENT

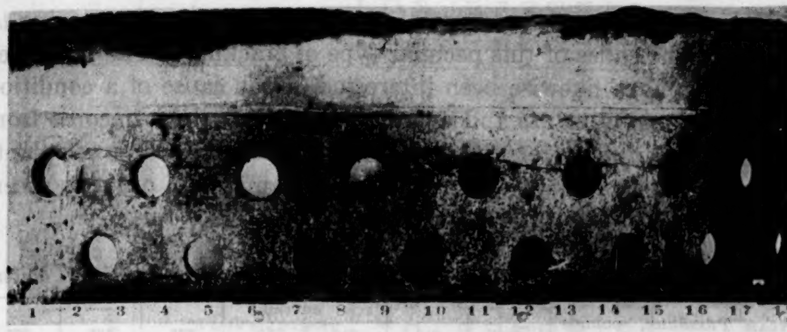

FIG. 2. EMBRITTLED PLATE FROM BUTT SEAM

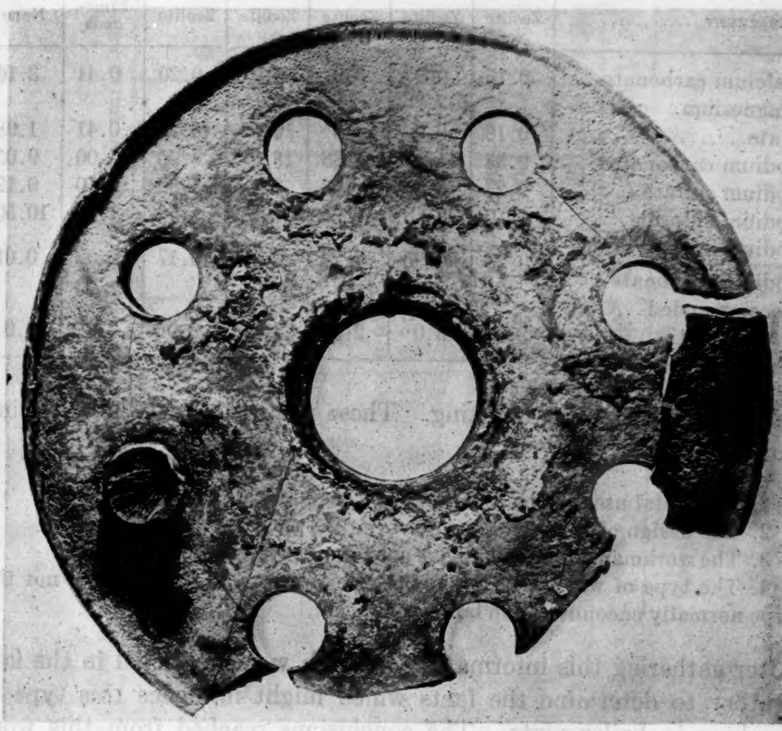

FIG. 3. EMBRITTLED BLOW OFF FLANGE

CAUSES OF EMBRITTLEMENT

For years the manufacturers of steam boilers have been trying to ascertain the cause of this peculiar type of cracking. The insurance companies have likewise been interested in the cause of a condition which endangers plants and operators. The available records from the boiler manufacturers, the insurance companies, and power plants experiencing this difficulty have all been examined in order to ascertain the cause of this cracking. These records reveal the following facts:

TABLE 1

Analyses, in grains per U. S. gallon, of feed waters used in embrittled boilers

Steam Pressure, pounds gage	200	250	200	30	225	265	225
Source of Water	Lake	River	Lake	Well	Lake	Lake	Well
Treatment	Zeolite	Zeolite	Zeolite	Zeolite	Zeolite	Lime-Soda	None
Calcium carbonate	0.15	0.0	0.0	0.0	0.20	0.41	3.16
Magnesium carbonate	0.10	0.0	0.0	0.0	0.29	0.41	1.98
Sodium carbonate	9.33	11.47	5.83	18.9	8.90	4.00	9.05
Sodium sulfate	2.23	10.30	1.63	2.0	1.50	2.10	0.12
Sodium chloride	1.10	3.18	1.25	1.6	1.50	1.34	10.50
$\frac{\text{Sodium sulfate}}{\text{Sodium carbonate}}$	0.23	0.90	0.28	0.10	0.17	0.52	0.01
Recommended A. S. M. E. ratio	2.0	3.0	2.0	1.0	2.0	3.0	3.0

1. The metal used in the boiler has not been at fault.
2. The design of the boiler has not been the cause.
3. The workmanship involved has not been at fault.
4. The type of water in use has been common to all cases and is not the type normally encountered in boiler operation.

After gathering this information research was conducted in the laboratory to determine the facts which might influence this type of cracking in boiler plate. The conclusions reached from this work are:

1. Embrittlement in boiler plate is caused by the combined action of stress and chemical attack. The stresses have been inherent in the construction

TABLE 2

Analyses, in grains per U. S. gallon, of surface waters in Illinois in which no cases of embrittlement are known

	Reservoir, Carter	Fox River, Elgin	Rock River, Rockford	Embarass River, Lawrenceville	Mississippi River, Chester	Mississippi River, Quincy	Mississippi River, Moline	Illinois River, Kampeville	Illinois River, Peoria	Illinois River, Lasalle	Big Vermilion River, Danville
Calcium carbonate	0.98	6.09	6.09	4.94	4.85	4.73	4.30	5.35	5.56	5.20	6.52
Magnesium carbonate	0.71	6.03	5.01	4.05	3.21	3.21	2.61	4.02	4.21	4.42	5.03
Sodium carbonate											
Sodium chloride	0.50	0.49	0.44	3.26	0.49	0.42	0.33	1.44	1.25	1.25	0.43
Calcium sulphate	0.43	1.80	0.60	1.07	2.09	0.67	0.67	2.02	2.13	2.82	1.73
Sodium sulfate	0.92	1.37	1.25	0.95	2.61	1.44	1.36	1.48	1.89	1.36	1.80
Iron oxide and alumina	0.15	0.02	0.08	0.04	0.03	0.04	0.03	0.02	0.02	0.02	0.02
Silica	0.93	0.69	0.87	0.99	1.28	1.04	0.93	0.69	0.69	0.69	0.82
Total solids	4.62	16.49	14.34	16.30	15.02	11.55	10.25	15.02	15.75	15.75	16.35

and operation of the boiler, while the chemical attack is caused by sodium hydroxide in the boiler water.

2. Certain methods of water treatment tend to convert some safe waters into the characteristic type which produces embrittlement.

3. The presence of sodium sulfate in the feed water tends to retard the embrittling effect and, if present in proper proportions, will stop it entirely.

4. The presence of phosphates and tannates will inhibit the embrittling action of caustic soda.

5. Methods for the introduction of some of these inhibiting agents to feed waters have been worked out and are in operation in large power plants.

6. No steel suitable for boiler plate has been found which is resistant to the embrittling action of caustic soda.

TABLE 3

Analyses, in grains per U. S. gallon, of boiler waters from embrittled boilers

Steam Pressure, pounds gage	200	250	200	30	225	265	60
Source of Water	Lake	River	Lake	Well	Lake	Lake	River
Treatment	Zeolite	Zeolite	Zeolite	Zeolite	Zeolite	Lime-soda	Zeolite
Sodium hydroxide	85.4	24.3	216.0	25.6	63.2	99.2	51.2
Sodium carbonate	69.2	10.5	74.9	25.5	11.3	25.9	12.4
Sodium sulfate	44.7	36.2	56.6	13.3	14.9	82.6	3.6
Sodium chloride	27.3	24.4	87.5	33.9	18.7	45.0	
Total alkalinity as Na_2CO_3	188.0	44.5	36.1	61.1	94.8	164.9	84.1
$\frac{Na_2SO_4}{\text{Alkalinity as } Na_2CO_3}$	0.24	0.81	0.15	0.21	0.15	0.50	0.04
Recommended A. S. M. E. ratio	2.0	3.0	2.0	1.0	2.0	3.0	1.00

DESCRIPTION OF WATER FROM EMBRITTLED BOILERS

The feed water used in embrittled boilers has always been found to contain sodium carbonate with the sodium sulfate content low. Table 1 gives the analyses of feed waters which have been used in embrittled boilers and shows how the sodium carbonate always predominates over the sodium sulfate. Table 2 contains the analyses of waters which have been used for years in boilers which have never encountered this trouble. It shows the absence of sodium carbonate.

The sodium carbonate in the feed water breaks down under the conditions of pressure and temperature encountered in the boiler to form sodium hydroxide and liberates carbon dioxide which goes

off with the steam. Table 3 gives the analyses of boiler waters from embrittled boilers which serve to illustrate the extent to which this decomposition takes place.

When it is found that this type of water is common to embrittled boilers the question as to how this type of water is obtained becomes important. A study has been made of the various water supplies and methods of treatment to determine how this type of feed water is obtained. It has been found that it occurs either as a natural water or as the result of water treatment.

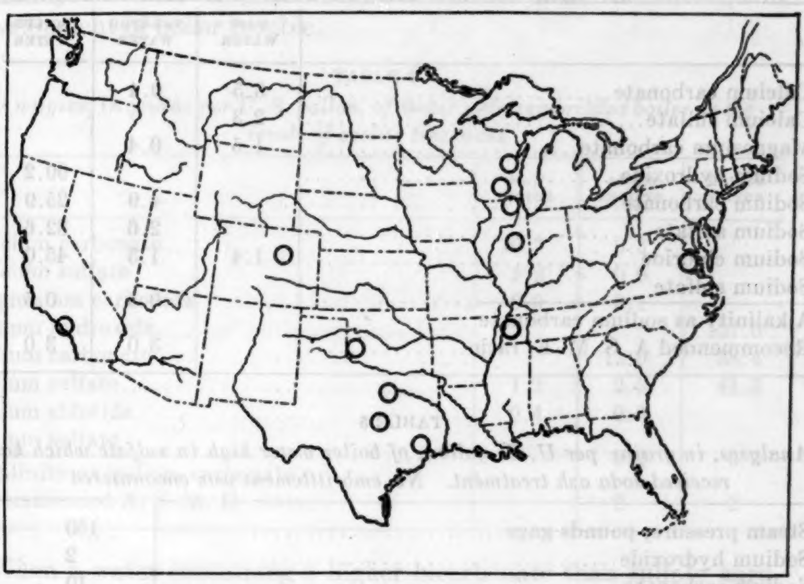

FIG. 4. AREAS IN WHICH BOILERS USING WELL WATERS HAVE BEEN EMBRITTLED

The natural waters which contain sodium carbonate are with few exceptions obtained from wells. The map shown in figure 4 shows the districts in which sodium carbonate well waters have caused embrittlement. This map is not complete, since it is known that other districts do have this type of water and it is not unreasonable to assume that embrittlement may occur in these other districts. Much recognition has been given to these natural waters as potential embrittling types. In many instances suitable water treatment has been tried in the past with the result that the occurrence of this trouble on these waters has been decreasing in the last few years.

A water which contains sodium carbonate in excess of the sodium sulfate as the result of water treatment cannot be isolated in any district nor can it be predicted unless complete data are available regarding the source of supply and the complete treatment used. A water may be changed to the embrittling type by either the lime soda or zeolite systems of softening.

TABLE 4

Analyses, in grains per U. S. gallon, of water which embrittled boiler due to excess soda ash treatment

	RAW WATER	TREATED WATER	BOILER WATER
Calcium carbonate	3.5	0.4	
Calcium sulfate	2.3		
Magnesium carbonate	1.5	0.4	
Sodium hydroxide			99.2
Sodium carbonate		4.9	25.9
Sodium sulfate		2.6	82.6
Sodium chloride	1.4	1.3	45.0
Sodium sulfate / Alkalinity as sodium carbonate		0.5	0.5
Recommended A. S. M. E. ratio		3.0	3.0

TABLE 5

Analyses, in grains per U. S. gallon, of boiler water high in sulfate which has received soda ash treatment. No embrittlement was encountered

Steam pressure, pounds gage	150
Sodium hydroxide	2
Sodium carbonate	10
Sodium sulfate	200
Sodium sulfate / Alkalinity as sodium carbonate	15.4
Recommended A. S. M. E. ratio	2.0

If a water containing a low sulfate hardness is treated by the lime soda system and the soda ash content is not carefully controlled the water becomes embrittling in nature. A recent case of embrittlement which resulted from the use of such treatment on a lake water will serve to illustrate this fact very vividly. The water used was from one of the great lakes and to facilitate softening the soda ash treatment was carried to the point where the sodium carbonate alkalinity

was between 4.5 and 5.0 grains in the treated water while the sodium sulfate was but 2.1 to 2.7 grains. Table 4 gives the analyses of the raw, treated water and boiler water from this plant and shows the extent to which the overtreatment with soda ash was carried. In table 5, the analyses of a boiler water resulting from treating a high sulfate water with soda ash are given to show that in this instance which encountered no trouble the excess of soda ash would be prohibitive before causing trouble. These serve to illustrate the fact that the use of the lime soda process on low sulfate waters must be carefully watched to prevent overtreatment with the subsequent development of boiler trouble.

TABLE 6

Analyses, in grains per U. S. gallon, of water which embrittled boiler as the result of zeolite treatment

	RAW WATER	AFTER ZEOLITE	BOILER WATER
Calcium carbonate	10.7	0.3	
Calcium sulfate	1.2	0.0	
Magnesium carbonate	6.0	0.1	
Sodium hydroxide			127.0
Sodium carbonate		12.0	38.4
Sodium sulfate	1.2	2.5	41.3
Sodium chloride	0.4	0.6	
Sodium sulfate / Alkalinity as sodium carbonate		0.2	0.2
Recommended A. S. M. E. ratio		2	2

When a water containing a higher bicarbonate than sulfate hardness is softened by the zeolite or base exchange process of softening, the sodium carbonate predominates over the sodium sulfate with the production of a water of the embrittling type. The increase in softening of waters of low sulfate hardness in recent years has brought about the adoption of this system of softening for these waters and apparently in step with this increase is the number of cases of embrittlement which may be traced to this type of softening. Table 6 gives the analyses of a raw water, the same after zeolite treatment, and the water from a boiler using the treated water and shows how the alkalinity has been increased to the point where it becomes dangerous for boiler feed water. The power plant using this water encountered embrittlement after fifteen months operation of new boilers on this water.

METHODS OF WATER TREATMENT TO PREVENT EMBRITTLEMENT

With the increase in demand for cleaner boilers, to be run at higher pressures and higher ratings, comes a greater demand for the softening of low sulfate waters by the lime soda and zeolite process, and with this an increase in the number of embrittling types of waters produced and a subsequent increase in the number of instances of embrittlement. It has already been shown how easily a non-embrittling type of water may be converted to the embrittling type. Since this is being done so very much at present the men dealing with water softening problems should recognize this fact and be in position to advise the power plants how to prevent this trouble.

The preventive methods to be used may be classed as follows: 1, sulfate treatment; 2, tannate treatment; 3, phosphate treatment.

Sulfate treatment

In view of the evidence that, when a proper sodium sulfate to sodium carbonate alkalinity ratio is maintained, embrittlement is prevented, the sulfate treatment has been used in many plants. The A. S. M. E. boiler code for 1926 recommends that a definite ratio be carried depending on the steam pressure of the boiler. These ratios are as follows:

PRESSURE, POUNDS, GAGE	RECOMMENDED RATIO	
	Sodium carbonate alkalinity	Sodium sulfate
Up to 150	1	1
150 to 250	1	2
Over 250	1	3

The University of Illinois power plant had experienced embrittlement trouble for years as the result of using a well water having sodium carbonate present. In 1915 a sulfate treatment was adopted maintaining the sodium sulfate twice the sodium carbonate alkalinity for boilers operating at 160 pounds pressure and no further trouble has been experienced. Various power plants have been using the sulfate treatment with freedom from embrittlement, while plants operating on similar waters not using the sulfate treatment have had embrittlement.

The sulfate treatment may be accomplished by any means which will increase the sodium sulfate to the desired amount. Some

plants use aluminum, iron, or magnesium sulfate, some add sodium sulfate, some mix high sulfate waters with those having low sulfate; others use sulfuric acid treatment, etc. Each method has its proper field of application. A water high in sodium carbonate content can be acid treated when proper chemical control is available. The alkalinity is reduced at the same time as the sulfate is raised. A water low in sodium carbonate alkalinity may be suitably treated by adding sodium sulfate, etc. A few typical cases will serve to illustrate how the sulfate treatment is accomplished. A plant having a well water containing about 4 grains per gallon of sodium carbonate and no sulfate uses the water for boilers operating at 160 pounds gage pressure. The make up to the boiler is high and the help available is not suitable for good chemical control. Lime softening tanks have been in use and filters are also available. By means of adding a definite amount of aluminum sulfate following the lime the sulfate content is increased and a precipitate of aluminum hydroxide is formed which helps the settling and subsequent filtration. Analyses are made from time to time to prevent overtreatment with aluminum salt and to see that the proper sulfate ratio exists. Another plant has the zeolite system in use on a low sulfate water. The treated water has 12 grains of sodium carbonate and but 3 grains of sodium sulfate. The boiler operates at 225 pounds gage pressure and it is desirable to increase the sulfate to three times the sodium carbonate alkalinity. By suitable means of proportioning, sufficient sulfuric acid may be added to the treated water to maintain the desired ratio. The total solids going to the boiler are not increased. Good chemical control must be maintained to make certain that the proper ratio is maintained without overtreatment with acid.

Tannate treatment

The use of tannin in the research laboratory showed that it had value as an inhibitant, yet its application to boiler water is very limited. To use any chemical to prevent embrittlement its determination in the boiler water is essential. It would be well to emphasize at this time that the actual determination of the content of the boiler water is essential and the composition of feed water is not sufficient to determine what will be the result of the action of the water in the boiler. At present there is no method of determining the tannin which is present in the boiler water. Until such tests are available or until a sufficient number of plants have operated on

a specified tannin treatment to show definite results no recommendations for its use can be made. It might be well to state that the tannin does not inhibit embrittlement by stopping decomposition of the sodium carbonate in the boiler. Tannin and other organic matter has been shown to influence the ordinary titration results so as to indicate that higher carbonates are present than are actually so and not to retard the decomposition.[4]

Phosphate treatment

Laboratory experiments show that phosphate, like sulfate and tannin, will serve as an excellent inhibitant of embrittlement in the laboratory tests. Like sulfate, the phosphate can readily be determined in the boiler water and its use as an inhibitant of embrittlement in boilers deserves some consideration. Sodium phosphate in alkaline waters will precipitate the calcium salts as the insoluble phosphate and if it is to be used in boiler waters as an inhibitant of embrittlement this fact must receive consideration. Sodium phosphate has been used in combination with sodium carbonate for water treatment on boilers which have encountered embrittlement. The phosphate was all precipitated and no soluble phosphate remained in the boiler water. To be effective as an inhibitant the sodium phosphate must be maintained in the boiler as soluble phosphate in definite amounts. This means that phosphate treatment involves the analyses of the boiler water from time to time to determine the amounts of alkalinity and soluble phosphate present, and to determine from these analyses the proper proportion of the phosphate to be used.

At present plants are in operation which are using the phosphate to replace the sulfate treatment for the prevention of embrittlement. The advantages of the use of phosphate treatment are as follows: it can be used in small amounts; it is non-corrosive and overtreatment does not involve any danger.

A general recommendation for the universal use of phosphate to prevent embrittlement should be avoided. It has a suitable field and like the other chemicals should only be used under the direction of one familiar with its use in water conditioning. Improper application of phosphate will defeat the purpose for which it is to be used.

[4] R. E. Hall, Bulletin 24, Carnegie Institute of Technology, 1927. A physico-chemical study of scale formation and boiler water conditioning.

A few examples of the possible application of the phosphate treatment will serve to show its limitations.

A power plant has a water for make up which has been zeolite treated. Consequently the feed water has about 15 grains of sodium carbonate and but 5 grains of sodium sulfate. The boilers operate at 600 pounds gage pressure. To meet the sulfate ratio it would be advisable to carry at least 6 to 1 sulfate carbonate ratio. The percentage make up is low and condenser leakage varies between moderately low limits. Due to the fact that the water has been zeolite treated and the condenser leakage is low, there is no scale difficulty. The acid treatment involves neutralization to the point where corrosion to treating and storage equipment becomes troublesome and expensive. Within the boilers no corroson is encountered due to the high alkalinity. If it is possible to substitute the phosphate treatment in place of the sulfate treatment the phosphate can be added as disodium phosphate in small amounts so as to carry a rather low phosphate content. As low as three or four grains of soluble PO_4 radical may serve adequate in the boiler water if the alkalinity is not too high. To maintain this condition sufficient phosphate must be added to precipitate the calcium salts which pass the softener as well as those which enter through condenser leakage and have a soluble excess. Thus a high condenser leakage may use up all the soluble phosphate and leave the boiler unprotected. This shows that a constant analysis of the boiler water must be made to determine the soluble phosphate and that analyses of the feed water are inadequate for this work.

Another plant using evaporators to furnish the make up water to the boilers is using water containing sodium carbonate. Due to carry over from the evaporators the feed water has between $\frac{1}{4}$ and $\frac{3}{4}$ grain of sodium carbonate without an appreciable amount of sodium sulfate. Sulfuric acid treatment of this water is impossible. The addition of a sulfate salt will increase the total solids and defeat the purpose of evaporation. If possible to recommend phosphate for this plant enough disodium phosphate would be added to take care of condenser leakage and still leave an excess to prevent the caustic alkalinity from embrittling the boiler. It would also be necessary to determine the alkalinity and the soluble PO_4 radical at regular intervals in the boiler water. The total solids would not be increased by over 3 grains per gallon in the boiler water.

SUPERVISION OF PUBLIC WATER SUPPLIES BY THE TENNESSEE STATE DEPARTMENT OF PUBLIC HEALTH[1]

By A. E. Clark[2]

Supervision of public water supplies by state departments of health has become recognized practically all over the United States. The machinery and laws to exercise this supervision vary considerably from those states which have adopted numerous regulations, vesting a great deal of authority in the state department of health, to those in which there are few, if any laws or regulations. In the latter case, it becomes necessary to obtain improvements almost entirely through coöperation. This, of course, is the most satisfactory method, but there are instances where it is impossible to get any action in this way. The aim is to have all public water supplies produce safe water at all times. The owner of a public water supply, whether municipal or private, assumes a definite responsibility to give the consumers safe water at all times. The courts have upheld this responsibility in enough cases to establish a precedent, where it has been proven that contaminated water from a public water supply has been responsible for typhoid fever.

In order to produce a safe water, sufficient equipment with the proper operation is necessary. Too often a plant is provided with good equipment, but due to inefficient operation, or probably lack of knowledge of its operation, it is allowed to get out of order, thus giving the consumer a false sense of security.

Many times the city officials themselves believe the water plant is producing a safe water, and that the equipment is in excellent condition, only to find on investigation that the expenditure of considerable money is necessary to place the plant in satisfactory operating condition. The city officials too often do not realize the water works can and should be compared to a factory. The factory under poor management eventually fails to be on a paying basis. So it is with

[1] Presented before the Kentucky-Tennessee Section meeting, January 19, 1928.

[2] Associate Sanitary Engineer, State Department of Health, Nashville, Tenn.

the water plant. With new equipment results are often obtained for varying periods of time, in spite of poor operation, but lack of proper management, knowledge, and interest are bound to work to the detriment of the plant.

Proper supervision of public water supplies by the state department of health is of material benefit to the water works and the health departments.

In Tennessee there are one hundred and thirty-seven (137) public water supplies. Four are under technical supervision with laboratory control, and eight are under lay supervision with both chemical and bacteriological or chemical control. One hundred and thirty (130) of the public water supplies are in towns of ten thousand (10,000) and less population. Forty-three obtain water from wells in the western grand division of the state and do not require any method of purification except iron removal. The remainder of the supplies are located in the central and eastern grand divisions and obtain water for the most part from springs and surface sources, both of which are subject to contamination.

In outlining a program for the supervision of the water supplies it was first necessary to obtain reliable bacteriological data. To do this a rule was made that a sample should be submitted each month, in sterile bottles furnished by the State Department of Public Health, from every public water supply. There are seventeen full-time county health departments, and three counties having the sanitary officer plan. There are fifty public water supplies in those twenty counties, and the sanitary inspector in each county is asked to collect a monthly sample from each public supply. The samples from the remainder of the supplies in the state are collected by the official in responsible charge of the water works. This rule has been in effect for two years, and the average number submitted each month is about 73 per cent. Use is made of a spot map of the state on which every public water supply is denoted by a suitable symbol. Examinations showing the water to be free from contamination are spotted with a white map tack, and those contaminated by a red tack, and if a sample is not submitted by a black tack. The size of this map is 5 by 2 feet. The next step in the program was to institute regular investigations of each supply. This has been tentatively set at two each year. Another spot map similar to the one used for water samples is used. One colored map tack is used for the first six months period, and another color for the last six months period.

Blank forms were mimeographed for what is called a master report, and these have been filled in for each supply in the state. These forms cover a very complete description of the plant. General data from these sheets are transferred to a 5 by 8 inch file card for a ready reference. Another form used is called the field investigation report sheet. These sheets are filled out for each visit and after the report or letter is written, and data transferred to the filing card, they are attached to the master report and filed. That in general is the office system used for water supplies. The majority of the public water supplies in Tennessee are located in towns of population of 6000 and less, therefore, it was necessary to concentrate our efforts on these supplies. A number of supplies practicing purification are too small, or at least the local authorities think they are too small, to pay a sufficient amount to obtain good supervision.

How can the State Department of Health coöperate with the superintendent in order to get the results desired? Representatives of the State Health Department have the benefit of coming in intimate contact with every water supply in the state, and generally covering all types of plants and treatments. The water works superintendent is confined to his own plant, or possibly a very few plants in the immediate vicinity. His duties, especially in small towns, are multifarious, acting possibly as water works superintendent, street superintendent, looking after the sewage disposal plant, if there is one, and many other duties. Under these conditions his time has to be divided among the various activities and he is not able to give sufficient attention to any particular job. The operators of purification plants in very small towns have had practically no experience in the operation of a plant of this character. Many times his only instruction consists of those given to him by the contractor. The Health Department, with the help of the superintendent, can often convince the city officials that more attention should be given to the water plant, and in that way secure more satisfactory operation. A large number of superintendents have a great deal of interest in the plant and are anxious for help and advice which will enable them to get better results. Here again the Health Department can assist the superintendent. Another class of superintendents, fortunately small in number, consider advice or assistance unnecessary and look with suspicion on the engineers from the Health Department, taking the attitude of letting the representative find what he can, if he can. Plants operated by this class of superin-

tendents often need improvements more than those operated by superintendents who are looking for assistance. The Health Department representative cannot be expected to remember all the details of a plant or to spend sufficient time at any one plant to be as familiar with it as the superintendent. During continuous operation by one man questions of methods of operation arise with which he is not acquainted. The Health Department can in the majority of instances give him the assistance he needs, or if unable to do it tell him where help is to be had. Exchange of information works to the advantage of both. The Health Department representative is in contact with all plants and some particular problem arising may have been solved by another superintendent, or he may have worked out some problem which would help another plant. The Health Department can help the superintendent in many instances to obtain needed improvements to the plant by taking the matter up with the city officials, and possibly presenting it in such a way that it will receive favorable attention.

If a water works superintendent has a real interest in his plant he is always willing to coöperate in every way. The Health Department is ready and willing to coöperate regardless of the superintendent's interest and does quite frequently arouse an active interest in plant operation by showing how certain improvements will benefit the plant. For instance, he may show them how the efficiency of the plant may be increased and better results obtained by the installation of equipment for chemical tests and the proper application of the results of these tests.

A water works superintendent sometimes feels that a Health Department representative is looking for something to find fault about. This is not the case. His interest is in improvements where necessary that will make for a safe water at all times. Our work is with the man in charge of the plant. If he works with us needed changes are generally made with very little trouble. He should feel at all times that the assistance and advice of the Health Department are at his disposal. When a condition arises with which he cannot cope he should immediately get in touch with the Health Department.

BACTERIUM COLI IN ICED AND UNICED SAMPLES OF WATER

By Gayfree Ellison,[1] H. Waton Hackler[1] and W. Alfred Buice[1]

The purpose of this investigation is to make a comparison of the number of Bacterium coli present in iced and uniced samples of water shipped by express to the laboratory for bacteriological analysis. We are unable to find any record of such an investigation having been made or published.

METHOD

Five duplicate samples of water were collected after the standard method and shipped by express at one-week intervals from each of twelve sources (Tahlequah City water, Bear Creek and certain wells and springs) located at Tahlequah, Oklahoma. Each sample from each source was duplicated in shipping, one of the duplicates being placed in an iced container and the other in an uniced container. The containers were of sheet iron and insulated with a 1-inch layer of cork. The containers were of a size about 10 by 10 by 12 inches, inside measurement. The samples were expressed from Tahlequah to Norman, Oklahoma, a distance of 200 miles. They were in transit from twenty to seventy-two hours. The ice in all the iced containers was melted on arrival at Norman, although in all instances, except one, the temperature of the container which had been iced was lower than that of the uniced. Immediately upon arrival at destination all samples were examined quantitatively for numbers of Bacterium coli according to the method prescribed on page 104 in Standard Methods of Water Analysis, Sixth Edition (1925). The duplicates of each sample were also tested with Koser's sodium citrate medium as per page 112 of Standard Methods to determine whether the lactose-fermenting organisms were of intestinal or of vegetable origin.

[1] Department of Bacteriology and Hygiene, University of Oklahoma, Norman, Okla.

From table 1 it is seen that 17 of the 60 samples showed a larger number of lactose-fermenting organisms per cubic centimeter in the

TABLE 1

Number of colon-aerogenes organisms per cubic centimeter on arrival at laboratory as revealed by quantitative tests

SOURCES	SANITARY CONDITION	SAMPLE 1		SAMPLE 2		SAMPLE 3		SAMPLE 4		SAMPLE 5	
		Iced duplicate	Uniced duplicate	Iced duplicate	Uniced duplicate	Iced duplicate	Uniced duplicate	Iced duplicate	Uniced duplicate	Iced duplicate	Uniced duplicate
Tahlequah City Water	From Illinois River. Rapid sand filter	0.1	10	10	10	10	10	1	1	10	1
Cliff House Spring	No protection from surface wash	100	10	100	100	10	10	100	100	100	100
Duncan Spring	Protected from surface wash	10	10	1	10	10	10	100	100	100	100
Big Spring	No protection from surface wash	1	1	10	100	10	100	100	100	100	100
McIntosh Spring	No protection	10	1	10	100	10	100	100	100	100	100
Winder Well	No protection	100	100	10	10	10	10	1	100	100	100
Bracket Well	No protection	100	100	1	1	10	10	1	100	100	10
Last Chance Well	No protection	100	100	1	100	1	100	10	100	100	100
W. T. Miller Well	No protection	100	100	1	1	1	10	100	100	10	100
Mart Miller Well	Drilled. Pump. Protected from surface wash	100	100	1	1	1	0.1	1	1	10	100
Leitch Well	Drilled. Pump. Protected from surface wash	100	100	0.1	10	10	10	10	100	10	10
Bear Creek	Open privies on banks	10	100	100	100	100	100	100	100	100	100

uniced as compared with the iced duplicates. Also, it will be noted that 5 of the 60 samples revealed a smaller number of lactose-fermenting organisms in the uniced as compared with the iced duplicates.

There were thus 38 samples of the 60 which showed the same number of lactose-fermenting organisms in the iced and uniced duplicates.

In Koser's sodium citrate medium 35 per cent of the gas-producing organisms in the tests of the duplicates appeared to be of vegetable origin and 65 per cent of intestinal origin.

Of the duplicates shipped on ice, 62 per cent gave tests for intestinal origin; while of the uniced duplicates 67 per cent proved to be of intestinal origin.

CONCLUSION

Our quantitative tests make it appear that it is of little importance whether samples of water shipped by express to laboratories for qualitative Bacterium coli tests are iced or uniced while in transit. However, it should be stated that in each instance the ice had completely melted when the samples arrived at our laboratory, although, except in one instance, all samples which had been iced were of a lower temperature on arrival than the uniced samples.

PHILADELPHIA'S WATER AT ITS WORST

By George G. Schaut[1]

Where a surface stream is the starting point in a purification process involving sedimentation, filtration and chlorination it is quite common to find organisms in the water even after chlorination which ferment lactose and are not members of the colon-group. In the case of Philadelphia all of its water comes from two rivers, the Schuylkill with a colon index of 26,900 per 100 cc. and the Delaware, with 27,500. Eighty per cent of the water is double filtered with the slow sand type as final filters.

One of the steps used in our laboratory after obtaining a positive presumptive test[2] or any gas in forty-eight hours, is to streak an eosin-methylene blue plate from the tube. In streaking on an eosin-methylene blue plate from a positive presumptive lactose broth tube the growth found may be either iodine metallic sheen in character, plain blue, pink with no blue, or a combination of these. Once in a while, however, round dark red isolated colonies are found. These isolated colonies have never given gas on re-inoculation into lactose broth and may be neglected in this paper. It is with the other three growths that this paper deals and especially with the pink growth, for, as noted later, it has constituted the doubtful growth. When re-inoculated into lactose broth tubes it sometimes gives rise to gas. Yet the same growth from the same sample of water but a different presumptive tube does not give gas when re-inoculated into lactose broth. This type of growth occurs mostly during the period of minimum temperature of water, or when the filters and chlorine are least efficient. This fact is illustrated in figure 1.

Using January and February as the worst time of the year, the data on bacterial forms are presented in table 1. The term "group" as used in this paper is purely arbitrary and has no connection with

[1] Chief Chemist, Bureau of Water, Philadelphia, Pa.

[2] All tube cultures (primary and secondary) for gas production were made using 30 cc. of medium.

the same word as used in the classification of chemical elements or bacteria.

The pink growth consisting of groups 6 and 7 is the doubtful one and bears the greatest influence upon the reporting of results due to the frequency with which it occurs. All tests were made on filtered water, after chlorination, as shown in table 2.

It is upon these groups that the Indol[3] reaction and the microscopic examinations were run simultaneously. The Indol reactions were made by taking a loopful from the eosin-methylene blue plates

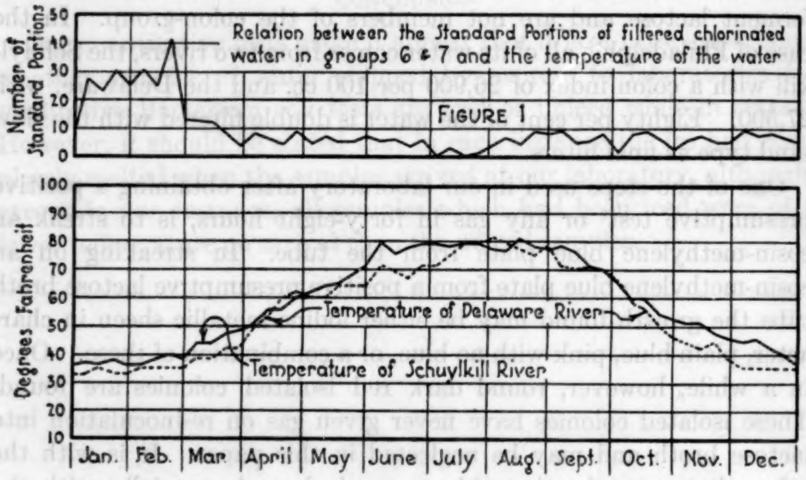

FIG. 1. RELATION BETWEEN 6 AND 7 GROUPS AND TEMPERATURE OF WATER

and inoculating two peptone broth tubes. These tubes were incubated at 37 degrees from one to four days. In the case of the iodine and blue streaks, positive Indol reactions were obtained at the end of twenty-four hours, whereas, it was necessary to carry the tubes from pink streaks four days. If after four days' incubation no Indol color develops in one hour the test was marked negative. During this work a number of potato cultures were made of group 6 and in no case was any growth obtained that might be typical of B. coli. The growth was without color and hardly noticeable.

The microscopic work consisted of making smears from secondary lactose broth tubes of these streaks and examining by Gram and

[3] Indol reaction according to A.P.H.A. Standard Methods of Water Analysis 1913, page 121.

TABLE 1

Data on bacterial forms in Philadelphia water

Group 1.	Ten per cent and over of gas in 24 hours in lactose broth, iodine metallic sheen growth on E.M.B.* plate, and gas on reinoculation into lactose broth
Group 2.	Ten per cent and over of gas in 24 hours in lactose broth, blue growth on E.M.B. plate, and gas on reinoculation into lactose broth
Group 3.	Ten per cent and over of gas in 24 hours in lactose broth, pink growth on E.M.B. plate, and gas on reinoculation into lactose broth
Group 4.	Less then 10 per cent in 24 hours and 10 per cent and over in 48 hours in lactose broth, blue growth on E.M.B. plate, and gas on reinoculation into lactose broth
Group 5.	Zero gas in 24 hours and 10 per cent and over in 48 hours in lactose broth, blue growth on E.M.B. plate, and gas on reinoculation into lactose broth
Group 6.	Zero gas in 24 hours and 10 per cent and over in 48 hours in lactose broth, pink growth on E.M.B. plate, and gas on reinoculation into lactose broth
Group 7.	Zero gas in 24 hours and 10 per cent and over in 48 hours in lactose broth, pink growth on E.M.B. plate and zero gas on reinoculation into lactose broth
Group 8.	Zero gas in 24 hours and less than 10 per cent in 48 hours in lactose broth, blue growth on E.M.B. plate, and gas on reinoculation into lactose broth
Group 9.	Zero gas in 24 hours and less than 10 per cent in 48 hours in lactose broth, pink growth on E.M.B. plate, and gas on reinoculation into lactose broth
Group 10.	Zero gas in 24 hours and less than 10 per cent in 48 hours in lactose broth, pink growth on E.M.B. plate, and zero gas on reinoculation into lactose broth
Group 11.	Ten per cent and over of gas in 24 hours, pink growth on E.M.B. plate and zero gas on reinoculation into lactose broth
Group 12.	Ten per cent and over of gas in 24 hours, no growth on E.M.B. plate in 48 hours
Group 13.	Less than 10 per cent gas in 24 hours, and 10 per cent and over in 48 hours, no growth on E.M.B. plate in 48 hours
Group 14.	Zero gas in 24 hours, and 10 per cent and over in 48 hours, no growth on E.M.B. plate in 48 hours
Group 15.	Zero gas in 24 hours, and less than 10 per cent in 48 hours, no growth on E.M.B. plate in 48 hours

* Eosin-methylene blue.

spore stains. The shape of the bacteria was also noted. In all the work the word "atypical" has reference to those not having the characteristic colon-shape, or in other words, do not look like colon bacteria. (See table 3.)

The laboratory carried this work still further and used lactose bile[4] and brilliant-green bile[5] for secondary inoculation, with results shown in table 4.

Where gas was obtained on brilliant-green bile with group 6 it was considerably less than 10 per cent and only appeared after forty-eight hours' incubation. In one case where gas was obtained on

TABLE 2

*Group tests made from January 1 to March 1, 1928, Standard Portions**

	TOTAL NUMBER OF TESTS	NUMBER OF TESTS IN Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15
F. W. B's†.....	1,550	5	10	8	1	19	225	236	4	12	8	1	8	3	297	19
District‡.......	653	5	2	1	0	10	114	76	1	6	7	0	1	0	149	7
F. W. B., Queen Lane, rapid sand.........	300	1	2	8	0	2	46	75	0	4	4	0	3	1	85	5

* Standard portion is 10 cc.

† Filtered water basins for all the plants.

‡ Various places in the distribution system.

lactose bile with group 6, spores were found in the tube culture. Group 14 in the case of brilliant-green bile was obtained by inoculating simultaneously lactose broth and brilliant-green bile tubes with the original sample of water. These results, as far as group 6 is concerned, are summarized in table 5.

Upon a like number of tests on group 7 using brilliant-green bile and lactose bile no tubes showed gas in forty-eight hours.

The Queen Lane plant is composed of two separate systems of filtration—the rapid sand plant and the slow sand plant. Both of

[4] Strength of lactose bile: 50 grams of Difco dehydrated Bacto-Oxgall per liter of lactose broth.

[5] Strength of brilliant-green bile: 70 grams of Difco dehydrated per liter of water. (Five per cent bile and 1/10,000 brilliant-green.)

TABLE 3

Indol and microscopic results of tests on the various groups

	INDOL			MICROSCOPIC EXAMINATION						
					Gram stain					
	Number of tests	Positive	Negative	Number of tests	Positive	Negative	Mixed	Typical	Atypical	Spores
Group 1 (10 per cent and over of gas in 24 hours in lactose broth, iodine metallic sheen growth on E.M.B. plate, and gas on reinoculation into lactose broth):										
F. W. B.'s	2	2		2		2		2		0
District	2	2		2		2		2		0
Group 2 (10 per cent and over of gas in 24 hours in lactose broth, blue growth on E.M.B. plate, and gas on reinoculation into lactose broth):										
F. W. B's	1	1		6		6		6		0
District	1		1	0						
Group 3 (10 per cent and over of gas in 24 hours in lactose broth, pink growth on E.M.B. plate, and gas on reinoculation into lactose broth):										
F. W. B.'s	3	2	1	2			2		2	2
District	0			0						
Group 4 (less then 10 per cent in 24 hours and 10 per cent and over in 48 hours in lactose broth, blue growth on E.M.B. plate, and gas on reinoculation into lactose broth):										
F. W. B.'s	0			1			1	1		0
District	0			0						
Group 5 (Zero gas in 24 hours and 10 per cent and over in 48 hours in lactose broth, blue growth on E.M.B. plate, and gas on reinoculation into lactose broth):										
F. W. B.'s	3		3	4		4		4		0
District	1	1		1		1		1		0

TABLE 3—*Continued*

	INDOL			MICROSCOPIC EXAMINATION						
					Gram stain					
	Number of tests	Positive	Negative	Number of tests	Positive	Negative	Mixed	Typical	Atypical	Spores
Group 6 (Zero gas in 24 hours and 10 per cent and over in 48 hours in lactose broth, pink growth on E.M.B. plate, and gas on reinoculation into lactose broth):										
F. W. B.'s	37	4	33	32	1	1	30	3	29	24
District	17	1	16	20	1	0	19	5	15	19
Group 7 (Zero gas in 24 hours and 10 per cent and over in 48 hours in lactose broth, pink growth on E.M.B. plate and zero gas on reinoculation into lactose broth):										
F. W. B.'s	16		16	17	1	2	14	3	14	14
District	10		10	6	1		5		6	5
Group 8 (Zero gas in 24 hours and less than 10 per cent in 48 hours in lactose broth, blue growth on E.M.B. plate, and gas on reinoculation into lactose broth):										
F. W. B.'s	1		1	1			1	1		0
District	0			0						
Group 9 (Zero gas in 24 hours and less than 10 per cent in 48 hours in lactose broth, pink growth on E.M.B. plate, and gas on reinoculation into lactose broth):										
F. W. B.'s	2	1	1	5	1	2	2	2	3	4
District	2		2	0						
Group 10 (Zero gas in 24 hours and less than 10 per cent in 48 hours in lactose broth, pink growth on E.M.B. plate, and zero gas on reinoculation into lactose broth):										
F. W. B.'s	2		2	2			2		2	2
District	0			0						

these systems draw water from the same sedimentation reservoir. In the case of the rapid sand filters the water passes through mixing chambers and coagulating basins, while the slow sand filters receive water from pre-filters of the rapid sand type without the use of a

TABLE 4

Brilliant-green bile and lactose bile tests upon the various groups

F. W. B.'s	BRILLIANT GREEN BILE		
	Number of tests	Positive	Negative
Group 1	2	2	0
Group 2	5	5	0
Group 4	4	4	0
Group 5	1	1	0
Group 6	55	3	52
Group 7	57	0	57
Group 8	1	1	0
Group 14	16	0	16
	LACTOSE BILE		
Group 6	55	22	33
Group 7	57	0	57

TABLE 5

Summary of group 6

GROUP 6	TOTAL NUMBER OF TESTS	PER CENT NEGATIVE
Microscopic	52	83*
Indol	54	91
Brilliant green bile	55	96
Lactose bile	55	60
	DISTRICT TESTS	
Microscopic	20	95
Indol	17	94

* Calculated on the presence of spores.

coagulant. During February, 1927, all the chlorine was applied after the water was filtered. However, in February, 1928, pre-chlorination on both plants was in use with a secondary dose after the water was filtered. In the case of the slow sand plant the water was chlorinated before passing to the pre-filters. It is interesting

to note the effect of pre-chlorination on the colon-index as shown in table 6. This index represents the probable number of colon organisms per 100 cc. and in the case of filtered, chlorinated water, it includes all organisms fermenting lactose broth on re-inoculation from eosin-methylene blue plates.

TABLE 6

Queen Lane filters—bacteria and colon-group*

	APPLIED WATER										FILTERED WATER BASINS CHLORINATED									
	Rapid sand filters					Slow sand filters					Rapid sand filters					Slow sand filters				
		Colon group organisms					Colon group organisms					Colon group organisms					Colon group organisms			
		Per cent of time present					Per cent of time present					Per cent of time present					Per cent of time present			
	Bacteria per cc.	0.01 cc.	0.1 cc.	1.0 cc.	Index	Bacteria per cc.	0.01 cc.	0.1 cc.	1.0 cc.	Index	Bacteria per cc.	1.0 cc.	10 cc.	5–10 cc.	Index	Bacteria per cc.	1.0 cc.	10 cc.	5–10 cc.	Index
February, 1927..........	680	11	64	96	1,640	572	0	43	93	480	5	0	19	14	1.9	5	0	8	13	0.9
February, 1928..........	25	3	7	24	400	28	3	3	17	360	9	0	24	25	2.8	5	0	24	23	2.8

* Agar 37°C., twenty-four hours.

TABLE 7

Queen Lane filters—chlorine in parts per million

	TOTAL TREATMENT		RESIDUAL (OUTLET OF BASINS)	
	Rapid sand filters	Slow sand filters	Rapid sand filters	Slow sand filters
February, 1927..........................	0.88	0.37	0.24	0.14
February, 1928..........................	0.95	0.72	0.15	0.12

Before pre-chlorination was practiced the chlorine dosage on the rapid sand plant was added in two places after filtration, one in the effluent conduit of the filters and a secondary dose in the filtered water basin. In February, 1928, when pre-chlorination was in use the double dosage of chlorine was applied in nearly two equal portions before and after filtration, on both plants. The increase in total chlorine used in the rapid sand plant was small as it was only a case of

moving the primary dosing point ahead of the filters. The residual, however, was very much less than the same month of the previous year. In the case of the slow sand plant it was necessary to double the total chlorine used in order to maintain practically the same residual as the previous year. The increase in chlorine used, by double dosage, seems to have no diminishing effect upon the organ-

TABLE 8

Queen Lane filters—colon index

	RAPID SAND FILTERS		SLOW SAND FILTERS	
	Index	True index	Index	True index
February, 1927	1.9	0.00	0.9	0.00
February, 1928	2.8	0.07	2.8	0.41

TABLE 9

Summary of colon-group tests made from January 1 to March 1, 1928

	TOTAL NUMBER OF TESTS	TOTAL NUMBER OF TESTS IN GROUPS 1, 2, 4, 5 AND 8	PER CENT OF TIME PRESENT
F. W. B.'s	1,550	39	2.5
District	653	18	2.8
F. W. B., Queen Lane, rapid sand	300	5	1.7

TABLE 10

Residual chlorine in parts per million

	JANUARY, 1928	FEBRUARY, 1928
At filter plants	0.17	0.16
One mile radius	0.10	0.11
Four mile radius, central business section	0.06	0.04

isms of group 6, but rather a beneficial one as their number greatly increased thus giving a higher index, as shown in table 7.

The writer feels that group 6 may be considered negative even though it gives gas on reinoculation into lactose broth, for the following reasons: (*a*) the large percentage of spores; (*b*) mixed colonies giving rise to the belief that the gas might be formed by symbiosis; (*c*) the bacteria were not typical in appearance; (*d*) high percentage of negative results on Indol and brilliant-green bile; (*e*) practically no

growth on potato; (*f*) the use of greatly increased dosage of chlorine does not reduce the number of tests falling in group 6, and (*g*) the inoculation of about two million people with these organisms during the first four months of the year corresponds to the minimum typhoid death rate. The effect of group 6 organisms is plainly seen if the in-

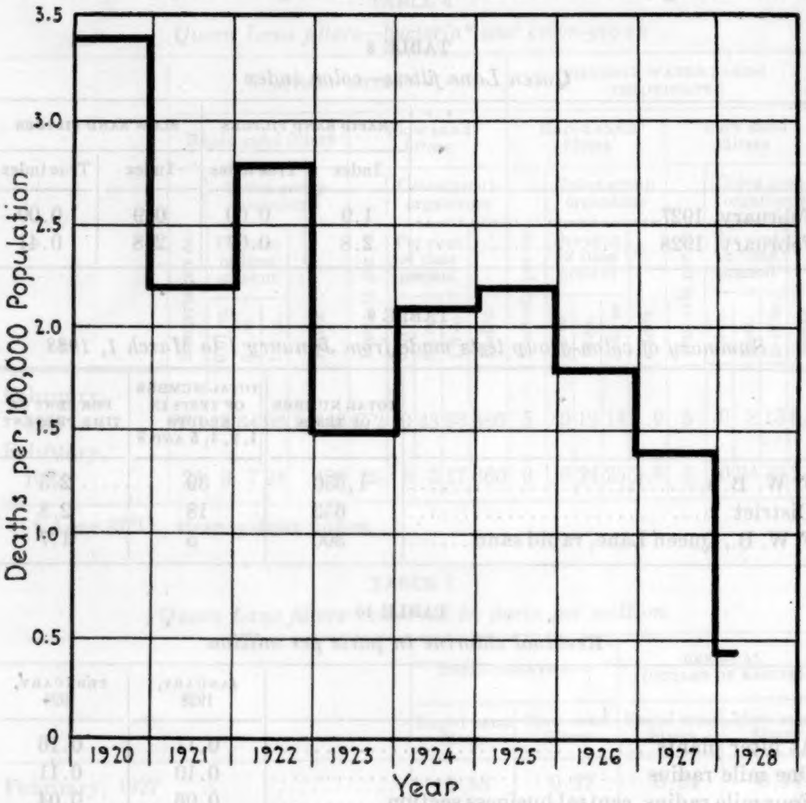

FIG. 2. TYPHOID FEVER DEATH RATES FOR PHILADELPHIA

dex is re-calculated, omitting those organisms belonging in group 6, and in this paper is designated by True Index.

From table 8 it is evident that this water is much better than the Treasury Department Standard, which allows not over one colon organism per 100 cc. and how easy it is to under-rate a good water, using the present Standard Methods without microscopic examination. The use of brilliant-green bile for secondary inoculation is

plainly justified and eliminates all microscopic work, except where desired for special research purposes. The Indol value of the water should not be overlooked as it is specific for recent pollution. Excluding group 6 and making a careful analysis of the figures in table 9 it is possible again to accurately evaluate the water. Using 1, 2, 4, 5 and 8 groups as being the true colon-group organisms it is seen that the water during the worst time of the year is far better than the Treasury Department Standard, which allows not over ten per cent of the tests to be positive. (See table 9.)

The residual chlorine at various places in a distribution system is of prime importance and the decrease in value as the water travels away from the point of initial application gives a fair idea of the chlorine consumption of the water. Characteristic data are shown in table 10.

In the final analysis, the result of any city's water is best reflected in its typhoid fever death rate. These rates are shown in figure 2. Only the first four months of 1928 were available at the time this paper was written. However, this shows the relation between typhoid death rate and the water at its most critical period of the year.

This paper would not be complete without mentioning the enthusiastic support the author received in its preparation, from Alex. Murdoch, Director of Public Works and formerly Chief Engineer of the Water Bureau, C. T. Hayes, present Chief Engineer of the Water Bureau, and also the members of the laboratory staff.

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CHLOROPHENOL TASTES IN WATERS OF HIGH ORGANIC CONTENT

By Louis B. Harrison[1]

Phenols and allied compounds in high dilutions, when chlorinated with a certain quantity of chlorine, produce chlorophenol taste. These tastes may be reproduced at will in the laboratory. In addition to these known substances, others, such as decomposition and cleavage products of organic matter, may be responsible for taste formation in waters where phenolic wastes are absent.

An interesting experiment in this connection has been performed by a chemist of the Dow Chemical Company at Midland, Mich. An infusion of oak leaves after filtration responded to the ferric chloride test, as phenols do.

It seems to the writer, however, from recent experiments that some workers confuse with chlorophenol tastes a chlorinous odor entirely due to an overdose of chlorine, and not to any combination of chlorine with phenolic wastes. At least in Bay City he has found it to be so and has had to search for different solutions in both cases. The failure to make the distinction may be responsible for the discrepancies in the results with various methods at different plants.

The writer has struggled with the problem since 1916. Invariably during the fall of the year after a southeast or northeast wind the tastes make their appearance in the chlorinated water. As the writer has stated in a former paper,[2] during these winds the Saginaw river water, highly polluted with industrial and sanitary wastes, is shoved over to the intake. The problem, however, became acute in the fall of 1925, when filtered water filled the city mains and the consumers had been advised that the water at the tap was safe for drinking purposes.

[1] Chief Chemist and Assistant Superintendent, Water Works, Bay City, Mich.

[2] Chlorophenol-like tastes in Bay City's filtered water supply, Journal, 15: 3, 1926.

Since 1925, the writer has experimented both on a laboratory and plant scale with superchlorination and dechlorination with sulfur dioxide; with chlorine-ammonia and with chlorine-permanganate.

SUPERCHLORINATION AND DECHLORINATION WITH SULFUR DIOXIDE

In 1927, the writer published a paper[3] on superchlorination of chlorophenol tastes. The results published in that paper expressed only laboratory findings and confirmed the researches of other workers.

In the fall of 1927, the necessary equipment was installed and set for the application of the method on a plant scale. Owing to the construction of the plant we found it impossible to superchlorinate the filter effluent and instead applied the chlorine to the raw water. The Wallace and Tiernan Company was kind enough to lend us an extra chlorinator for that purpose. At the time the process had already been in use at Toronto, Canada. Judging from the paper by Howard[4] it is still in use and produces highly satisfactory results. At Bay City the taste problem is an intermittent one. Inasmuch as it takes several hours after a change in wind before the water reaches the plant it is an easy matter to determine when to resort to remedial measures.

Table 1 gives an analysis of the water during the taste periods. The data cover a period of over four years. During normal conditions the average alkalinity of the raw water is 98 p.p.m., oxygen consumed 1.2 p.p.m. and color 8 p.p.m. A decided change in the three components takes place during the taste-forming periods. The turbidity often increases considerably. After a southeaster an increase in one of the components is sufficient to suspect a taste. An increase in color also is most likely to produce an intense taste after chlorination. Curiously enough, the water often reaches the plant with a decidedly chlorophenol taste before any chlorine has been added.

From table 1, it will be noted that on October 31, the first actual application of a super dose took place, although doses above the average were used since October 15, 1927. The dose of 2.69 p.p.m. chlorine left a heavy residual chlorine in the filter effluent. Sulfur dioxide had been used to remove the excessive residual chlorine,

[3] JOURNAL, 17: 3, March, 1927.

[4] JOURNAL, 19: 5, May, 1928.

leaving none in the finished product. Like other workers we have experienced difficulty in feeding small doses of SO_2. It was necessary to keep the sulfur dioxide tanks immersed in warm water. While a questionable chlorophenol taste appeared in the filter effluent after this treatment a distinctly nauseating musty or weedy taste also appeared. It is heroic to express preference in cases of disagreeable tastes, but the writer would at any time prefer the chlorophenol instead of the musty. Whether it may be classed as a side taste formed by the interaction of chlorine and the organic constituents of the water is hard to state.

In order to give the treatment a thorough trial, superchlorination was continued during November and December, 1927. On November 28 and 29, doses of 3.88 p.p.m. were applied and the results were highly disappointing. In addition to the regular, but much intensified chlorophenol tastes, we experienced nauseating side tastes. The last super dose was applied on January 15, 1928, with similar unsatisfactory results. In addition to the chlorophenol tastes the writer also noticed a distinct alum taste in the water. This occurred on November 28, 1927, when the dose of alum was increased from 0.9 to 2.45 p.p.m. Exactly what caused the alum to go into solution we cannot tell, unless it was the acidity produced by the large dose of chlorine. Superchlorination was continued until January 15, 1928, and then permanently discontinued. Superchlorination to remedy chlorophenol tastes proved a miserable failure with the type of water we have to treat during taste periods.

CHLORINE-AMMONIA TREATMENT

During 1928 and 1929, the writer experimented on a laboratory and plant scale with chlorine-ammonia and chlorine-permanganate treatments. The ammonia treatment has been reported on by J. W. McAmis, Greenville, Tenn., as giving good results.

Table 2 gives some interesting laboratory results. To three samples of water 0.1 p.p.m. of phenol and 0.2 p.p.m. of NH_3 were added. To bottles 1 and 2, 0.4 p.p.m. of $KMnO_4$ was added and an equal amount of chlorine to all three. After an hour's interval the samples were tasted independently by four observers. While no tastes appeared in samples 1 and 2, a distinct taste appeared in sample 3. The same experiment has been repeated using 0.2 p.p.m. of phenol and 0.5 p.p.m. of $KMnO_4$. The samples were kept for several days and tasted again in cold and warm state with the same

results, excepting that the taste became more intense on standing in sample 3. Similar experiments were conducted on gas plant wastes and wood distillation wastes with identical results. When permanganate was added to bottle 3, which had the distinct taste, and let stand for thirty minutes, the taste entirely disappeared.

The laboratory data proved conclusively that NH_3 cannot be resorted to as a means of preventing or destroying chlorophenol tastes. However, it was also tried out on a plant scale. On November 4, 1928, after a northeast wind, NH_3 was applied to the water about twenty minutes before chlorination, in doses of 0.25 p.p.m. and chlorine 0.48 p.p.m. (table 1). The final product developed a distinct chlorophenol taste.

The ammonia treatment has not been given up and its value has been well established at the plant, however, not as a destroyer of chlorophenol taste, but as a preventer of chlorinous odors.

PERMANGANATE-CHLORINE TREATMENT

The laboratory data in table 2, demonstrated that permanganate treatment when properly applied will prevent the formation of chlorophenol tastes when applied before the addition of chlorine, and will also destroy the tastes formed when applied after chlorination.

The treatment was tried out on a plant scale on November 16 and 18 and December 3, 1928, with highly gratifying results. In fact it was the first time since 1925 that no complaints were received at the office during the fall of the year.

On January 2, 1929, after a strong southeast wind, the Saginaw Bay froze over and pocketed river water. A change in wind had no more effect on it and the raw water started to come in with a very distinct chlorophenol taste, in fact much stronger than the writer could have dreamt of. Over a million gallons went through the plant without proper treatment and slight tastes appeared at the plant and in the city mains. As soon as the reaction was properly adjusted the tastes entirely disappeared. In spite of the fact that the water reached the plant for fifteen days with a very pronounced taste, the taste in the city mains lasted only two days and in a very faint form. The fact remains that there was not enough taste to call out resentment on the part of the consumers.

The long and continued duration of the tastes in the raw water made it possible to experiment with the waters. There is no doubt in the writer's mind that the permanganate-chlorine treatment

TABLE 1

Analysis of water during taste-forming periods and parts per million chemicals applied

DATE	ALKALINITY		OXYGEN CONSUMED		COLOR		pH		TASTE		TEMPERATURE RW °F.	CHLORINE APPLIED	NH_3 APPLIED	$KMnO_4$ APPLIED
	Raw	Filtered	Raw	Filtered	Raw	Filtered	Raw	Filtered	Raw	Filtered				
1925														
November 4	139									V.S.				
November 5	190		5.2							V.S.		0.25		
December 5	197		6.8							V.S.		0.63		
1926														
November 15	193	116	0.2	0	60	2	8.2	7.7	0		42	0.52		
November 16	194	124	11.1	5.2	60	18	8.0	7.5	F	V.S.	43	0.74		
November 26	185	117	6.0	2.8	50	20	8.3	7.9	F	V.S.	36	0.46		
December 1	145	135	6.6	4.7	35	10	8.3	7.8	D	V.S.	40	0.67		
1927														
October 31	146	125	4.5	2.2	35	8	8.2	7.7	0	?	55	2.69		
November 9	135	117	2.3	1.0	12	4	8.1	7.9	0	V.S.M.	41	2.15		
November 28	175	138	3.9	0.3	35	6	8.1	7.7	D	V.S.	42	3.88		
November 29	173	164	7.7	4.9	35	12	7.9	7.5	D	V.S.	43	3.22		
November 30	177	163	7.6	5.3	35	15	8.1	7.9	D	V.S.	44	2.38		
December 1	177	117	3.4	3.2	12	6	7.9	7.7	F	V.S.	42	1.76		

						1928								
November 4	125	123	3.9	2.3	25	8	8.5	7.9	F	S	46	0.48	0.25	
November 16	120	102	1.8	0	10	6	8.3	7.9	S	0	46	0.44	0.25	0.053
November 18	149	108	3.0	0	8	2	8.5	7.9	S	0	45	0.35	0.25	0.140
December 3	187	121	7.7	1.7	35	2	8.3	7.7	V.S.	0	39	0.58	0.25	0.580
						1929								
January 4	118	100	1.0	1.0	5	0	8.5	8.3	F	0	36	0.28	0.25	0.070
January 6	118	110	1.0	0.7	10	2	8.6	8.3	F	0	37	0.28	0.25	0.075
January 7	210	138	4.4	0.9	45	4	8.6	8.3	V.S.	F	34	0.30	0.25	0.070
January 8	190	161	2.4	0.8	35	6	8.6	8.3	V.S.	0	35	0.40	0.25	0.380
January 9	192	163	3.4	0.6	35	6	8.5	7.9	V.S.	0	37	0.52	0.25	0.820
January 10	180	169	1.4	0.6	30	6	8.5	7.9	V.S.	0	36	0.54	0.25	0.720
January 11	218	168	5.8	3.0	35	6	8.3	7.7	V.S.	0	34	0.54	0.25	0.700
January 12	203	169	6.2	3.9	25	6	8.1	7.9	V.S.	0	36	0.60	0.25	0.540
January 13	214	180	6.3	3.7	25	12	8.1	7.7	V.S.	0	35	0.50	0.25	0.760
January 14	207	152	6.1	3.7	35	8	8.1	7.5	V.S.	0	34	0.40	0.25	1.71
January 15	206	185	6.3	4.2	35	8	8.3	7.7	V.S.	0	35	0.46	0.25	1.55
January 16	142	150	2.9	2.8	12	4	8.5	7.9	V.S.	0	34	0.46	0.25	1.50
January 17	136	135	2.8	2.8	8	2	8.5	8.1	V.S.	0	36	0.30	0.25	0.50
January 18	134	125	3.7	2.8	7	2	8.5	8.1	V.S.	0	37	0.31	0.25	0.47
January 19	125	127	2.0	2.2	6	2	8.5	8.1	V.S.	0	37	0.20	0.25	0.21

is the most successful known at the present time in combating chlorophenol tastes at our plant. It still needs a great deal of study. The adjustment of the dose in conjunction with chlorine must be worked out more definitely. The permanganate must be applied in such quantities that all of it would precipitate out in the coagulation basin. It can only be applied to a water that is subsequently filtered. What manganese may cause in a water supply is well presented in a paper[5] by C. A. H. von Wolzogen Kuhr, and also by Frank E. Hale.[6]

Whether permanganate exerts its effects as an oxidizing agent only, or as an oxidizing and adsorbing agent remains to be studied.

TABLE 2

Effect of ammonia and permanganate on chlorophenol tastes

	Phenol						Gas plant waste, 1-5000			
	0.1 p.p.m.			0.2 p.p.m.						
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 2	Sample 1	Sample 2	Sample 3	Sample 4
NH_3	0.25	0.25	0.25	0.25	0.25	0.25	0	0	0	0
$KMnO_4$	0.4	0.4	0	0.5	0.5	0	0.1	0.2	0.3	0
Cl_2	+	+	+	+	+	+	+	+	+	+
Taste	0	0	V.S.	0	0	V.S.	0	0	0	V.S.

CONCLUSION

The writer of this paper has studied thoroughly in the laboratory and plant, the prevention and destruction of chlorophenol tastes by superchlorination and dechlorination, ammonia and chlorine and permanganate and chlorine, with the following results:

1. Superchlorination and dechlorination when applied to a water of high organic content and high color are ineffective.

2. Side tastes are produced which are even worse than the chlorophenol taste.

3. When applied with large doses of alum, an alum taste appears in the filtered water.

4. Superchlorination when applied to a clear water of high organic purity is successful, provided all traces of chlorine are removed after a certain contact period.

[5] Journal, 18: 1, July, 1927.

[6] Journal, 20: 5, November, 1928.

5. The ammonia-chlorine treatment is ineffective in preventing or destroying chlorophenol tastes.

6. It is very valuable as a means of overcoming chlorinous odors in certain types of water.

7. The permanganate-chlorine treatment is effective both as a destroyer and preventer of chlorophenol tastes in waters of high as well as low organic content.

8. The permanganate-chlorine treatment can not be applied to water that is not subsequently filtered unless the dose is minute.

9. The adequate relation between the dose of chlorine and permanganate and the reaction period must be carefully studied.

The writer of this paper wishes to express his thanks to his assistant B. B. Savage and his plant organization for their assistance in studying these problems.

UNITED STATES SUPREME COURT DECISION ON GREAT LAKES LEVELS CONTROVERSY[1]

The States bordering on the Great Lakes were held by the Supreme Court of the United States, on January 14, to be "entitled to a decree which will be effective in bringing the unwarranted part of the diversion" of the waters of Lake Michigan through the Chicago River for purposes of sewage disposal by the Sanitary District of Chicago to an end.

But the Court further held that "in keeping with the principles on which courts of equity conditon their relief, and by way of avoiding any unnecessary hazard to the health of the people of that section, our decree should be so framed as to accord to the Sanitary District a reasonable practicable time within which to provide some other means of disposing of the sewage, reducing the diversion as the artificial disposition of the sewage increases from time to time, until it is entirely disposed of thereby, when there shall be a final, permanent, operative, and effective injunction."

CASES REFERRED TO MASTER[2]

The cases were referred back to the Special Master, Charles Evans Hughes, on the exceptions to whose report the opinion of the Court was given, for the purpose of determining "the practical measures needed to effect the object just stated and the period required for their completion" and to recommend to the court a proper decree in the cases.

The decision of the court was reached in the cases of State of Wisconsin et al. v. State of Illinois and Sanitary District of Chicago, Nos. 7, 11, 12, Original. The opinion in these cases was delivered by Chief Justice Taft, there being no dissents thereto.

The lower Mississippi River States, which had intervened in the case, seeking recognition of their alleged rights in the navigation of the Mississippi and in the continued diversion of the waters of Lake

[1] Abstract of U. S. Supreme Court Decision, from the *United States Daily*, January 15, 1928.

[2] Journal, January, 1928, page 36.

Michigan so as to provide a ship canal from the Great Lakes to the Mississippi, were said by the Court, in the absence of any authority from Congress for a waterway from Lake Michigan to the Mississippi, to have no rightful interest in the controversy.

SEWAGE PLANTS REQUIRED

"The Sanitary District authorities, relying on the argument with reference to the health of its people," the opinion concludes, "have much too long delayed the needed substitution of suitable sewage plants as a means of avoiding the diversion in the future. Therefore they can not now complain if an immediately heavy burden is placed upon the district because of their attitude and course.

"The situation requires the district to devise proper methods for providing sufficient money and to construct and put in operation with all reasonable expedition adequate plants for the disposition of the sewage through other means than the lake diversion.

"Though the restoration of just rights to the complainants will be gradual instead of immediate it must be continuous and as speedy as practicable, and must include everything that is essential to an effective project."

CONSTRUCTED ARTIFICIAL CANAL

According to the findings of the Special Master, Charles Evans Hughes, during the period from 1892 to 1900, the Sanitary District of Chicago, acting as the agent of the State of Illinois, constructed an artificial canal from the Chicago River to the Des Plaines River for the purpose of carrying the sewerage of Chicago and other cities into the Des Plaines and Illinois Rivers.

Since the opening of this canal, the flow of the Chicago River has been reversed, being made to flow away from Lake Michigan toward the Mississippi River. The water directly abstracted from Lake Michigan by the Sanitary District, the court states, was increased from 2,541 cubic feet a second in 1900 to 7,228 in 1916 and 6,888 cubic feet in 1926, not including pumpage.

The diversion of the waters of Lake Michigan at Chicago of 8,500 cubic feet a second is now maintained, the opinion explains, under a permit of the Secretary of War of March 3, 1925, acting under Section 10 of the Act of 1899. The complainants had contended that this section vests no such authority in the Secretary of War.

TEMPORARY PERMIT ISSUED

The Sanitary District disobeyed a previous permit, the Court states, restricting the amount of water which could be diverted, in order to carry off the sewage. It was not practicable to stop the deposit without substituting some other means of disposal, it is explained, and in this situation, the Secretary of War, in the interest of navigation and its protection issued a temporary permit intended to sanction for a time being a sufficient diversion to avoid interference with navigation. The elimination of the interference with navigation was the sole justification for expanding the prior permit, the Court states.

Beyond the negligible quantity needed to maintain navigation in the Chicago River, the opinion continues, "the validity of the Secretary's permit derives its support entirely from a situation produced by the Sanitary District in violation of the complainants' rights; and but for that support complainants might properly press for an injunction of the diversion."

DECREE GIVEN WITHOUT PREJUDICE

In a prior proceeding (Sanitary District of Chicago v. United States, 266 U. S. 405), the Supreme Court affirmed a decree of a lower court, Chief Justice Taft explains in his opinion, enjoining the Sanitary District from a diversion of not more than 250,000 cubic feet per minute or its equivalent 4,167 cubic feet per second of water from Lake Michigan. The Supreme Court's decree, however, was given without prejudice to any permit that might be issued by the Secretary of War according to law.

Immediately after this decision, the opinion further states, the Secretary of War issued a permit on March 3, 1925 on certain conditions authorizing the Sanitary District to divert from Lake Michigan an amount of water not to exceed an annual average of 8,500 cubic feet per second. This is the permit upon which the Sanitary District relied for authority for the present diversion of water into the Chicago River.

"The conditions of the permit," it is further stated, "required the city of Chicago to take immediate steps to carry out sewage treatment by artificial processes, so that before the expiration of the permit they should provide the equivalent of 100 per cent treatment of the sewage of 1,200,000 people, or one-third of the population of the city," the

permit to be revoked if the conditions were not complied with, and the permit to cease unless renewed on December 31, 1929.

FOUND LAKES TO BE LOWERED

The Master found that the conditions had been complied with, as certified by the resident U. S. District Engineer.

The Special Master also found that the effect of the diversion of the waters of Lake Michigan has been a lowering of six inches in Lakes Michigan and Huron and five inches in Lakes Erie and Ontario, decreasing the carrying capacity of large lake vessels which carry 95 per cent of the freight from 540 to 600 tons per cargo.

In addition to the effect on lake transportation, Mr. Hughes found that the artificial lowering of the level of the lakes interferes with and obstructs the navigable capacity of channels and harbors, resulting in damage from decay and loss of support to docks and piers.

The damage due to the diversion, the Special Master found, relates to navigation, and commercial interests, to structures, to the convenience of summer resorts, to fishing and hunting grounds, to public parks and other enterprises, and to riparian property generally.

EDITORIAL COMMENT

The Cost of Water Borne Typhoid Fever

At the risk of being monotonous, it still seems desirable to point out to the water works profession, in the light of very recent episodes, that it is cheaper to prevent water-borne typhoid fever than to pay the costs of its occurrence. Within the past six months, further demonstrations of the extravagance of inadequate water supply protection have been again demonstrated.

On February 8, 1929, the Governor of New York State signed[1] an act authorizing the City of Olean to issue $350,000 in bonds to pay the damages and other costs of a recent water-borne typhoid fever epidemic. The bonds are to be redeemed through taxation for the next twenty years. In addition, a 50 per cent increase in water rates has been recommended by the Mayor. The City assumed responsibility for the hospital, medical and nursing expense involved in the epidemic. It also had to meet family relief problems created by the illness. During the epidemic there were 210 graduate nurses on the City payroll to care for the 230 cases and 22 deaths which occurred in the 27,000 inhabitants. Volunteer and official agencies responded with perfect coöperation. The costs in damages and other demands were $350,000. The expense to have prevented the epidemic would not have exceeded one-tenth of this amount.

In the early part of this year, the Court of Appeals of the State of New York confirmed[2] two judgments against the City of Albany, to recover damages because of the pollution of the water supply several years ago, when many persons contracted typhoid fever. A score of additional actions, which have been held in abeyance pending Court decision, will now be brought. The costs in typhoid fever damage verdicts will probably aggregate far in excess of the expense which would have been involved in preventing the epidemic.

[1] Health News, New York State Department of Health, January 28, 1929, page 14; February 11, 1929, page 24; March 4, 1929, page 34. Jour. Amer. Medical Assoc., March 16, 1929, page 906.

[2] Health News, New York State Department of Health, March 4, 1929, page 35.

Within the past year an estimate[3] has been published upon the monetary costs of the typhoid fever epidemic in Hanover, Germany, in 1926. The total costs involved in the deaths, sicknesses, insurance benefits, voluntary and official services, are indicated in excess of $1,000,000. The cost of prevention would have entailed an expenditure for the installation of duplicate chlorinators, probably less than one-tenth of the monetary cost of the epidemic.

In the early part of 1929, in the suburbs of Lyons, France, an epidemic of typhoid fever of water borne origin occurred.[4] The number of cases already reported has exceeded 2100, and the number of deaths 45. The epidemic has been definitely determined as of water borne origin, through the contamination of filter galleries or reservoirs by contact with a neighboring cesspool. Forty-one damage suits have already been instituted against the water company and the owner of the cesspool. The monetary costs of this epidemic will be heavy.

Even if it is true that the public is more interested in the dollar than in a death, ordinary principles of economy demand vigilant protection and eternal safeguarding of the water supply.

ABEL WOLMAN.[5]

[3] Die Hannoversche Typhusepidemie im Jahre 1926. By R. Mohrmann. Pub. Richard Schoetz, Berlin, 1927.

[4] Jour. Amer. Medical Assoc., February 2, 1929, page 403; February 16, 1929, page 576; February 23, 1929, page 662; March 2, 1929, page 736.

[5] Editor-in-Chief, Journal of the American Water Works Association; Chief Engineer, Maryland Department of Health.

SOCIETY AFFAIRS

KENTUCKY-TENNESSEE SECTION

The fourth annual meeting of the Kentucky-Tennessee Section was called to order by W. H. Lovejoy, Vice Chairman, who presided due to the absence of F. W. Albert, Chairman, at 10:00 a.m., Thursday, January 24, 1929. About one hundred members and guests were present.

The address of welcome was given by Charles J. Kellem, Secretary, Chattanooga Chamber of Commerce, and W. S. Cramer, Manager, Lexington Water Company, Lexington, Kentucky, gave the response.

Dr. E. L. Bishop, Commissioner, Tennessee Department of Public Health, gave an address on "The Necessity of Coöperation between the Water Works Operator and the Public Health Officials."

Mr. Beekman C. Little discussed the proposed changes in the constitution of the American Water Works Association and what should be done to improve the meetings of the sections and the parent association.

After appointment of various committees, the meeting adjourned until 1:30 p.m.

"Federal Requirements for Water Supplies Used on Interstate Carriers," was given by H. N. Old, Sanitary Engineer, United States Public Health Service, and was discussed by B. C. Little, A. F. Porzelius and W. H. Lovejoy.

"The Appraisal of Water Works Properties," by H. F. Wiedeman, was given and discussed by A. F. Porzelius and B. C. Little.

"Conservation by Metering," by F. R. Vannoy, was read and discussed by A. F. Porzelius and W. H. Johnson.

"Responsibility of Private Water Companies for Fire Losses," by Paul Hansen, was read by L. S. Vance and discussed by F. C. Dugan, James Sheahan, Albert Clemens, W. S. Cramer, W. H. Lovejoy, L. S. Vance, A. F. Porzelius, B. C. Little, H. N. Old and W. S. Patton.

The nominating committee reported the following officers have been selected for the coming year: W. H. Lovejoy, Chairman; A. E. Clark, Vice-Chairman; C. A. Orr, Director and A. F. Porzelius, Director.

In the evening a smoker was given under the auspices of H. M. Lofton and his associates of the Columbian Iron Works.

On Friday, January 25, 1928, the first paper given was "Industries and Public Water Supplies," by Wellington Donaldson. The paper was discussed by A. F. Porzelius, H. R. Fullerton, M. B. Whitaker, J. W. McAmis, H. G. Menke and F. C. Dugan.

"A State Health Department View of the Stream Pollution Problem," was read by Roy J. Morton, and was discussed by F. C. Dugan, A. F. Porzelius, Wellington Donaldson and W. H. Lovejoy.

"Water Works Requirements for Fire Protection," by E. T. Holman, Tennessee Inspection Bureau, Nashville, Tennessee, brought discussion from James Sheahan, L. S. Vance, H. K. Bell, W. S. Patton, W. S. Cramer, A. F. Porzelius, H. F. Wiedeman and Albert Clemens.

"Corrosion from a Practical Water Works View Point," by J. W. McAmis, was read. It was discussed by W. S. Patton, B. B. Hodgman, L. S. Vance, A. F. Porzelius, W. H. Lovejoy, W. S. Cramer, S. F. Moser, H. K. Bell and T. M. Starnes.

"The State Sanitary Engineer, The Water Works Operator and The Consulting Engineer," by C. N. Harrub, brought considerable discussion from F. C. Dugan, H. F. Wiedeman, H. K. Bell, R. J. Morton, W. H. Lovejoy and W. H. Johnson.

At the Round Table Discussion, the following subjects were offered:

"Water Rates," by James Sheahan.

"Distribution Systems," by M. B. Whitaker.

"Financing Water Main Extensions," by W. S. Cramer.

"Fire Hydrant Rentals," by A. F. Porzelius.

"The Place of the Technically Trained Men in Water Works Business," by H. K. Bell.

"Should the Water Department Concern Itself with the Matter of Sewage Disposal and Industrial Wastes," by F. C. Dugan.

On Friday evening the annual dinner dance was held at the Hotel Patten.

On Saturday morning, the first paper was "Water Meter Practice," by R. C. Workman, and was discussed by L. S. Vance, F. R. Vannoy and James Sheahan.

"Pumping and Filtration Costs of a Small Town Water System," was given by W. S. Davis, Tennessee Electric Power Company,

Harriman, Tennessee. This paper was discussed by W. S. Patton, W. H. Lovejoy and W. S. Cramer.

Reports of committees were then presented.

The Chairman announced that F. C. Dugan had been re-elected Secretary and Treasurer.

The City Water Company of Chattanooga entertained the Section until luncheon at their plant and arranged for a sightseeing trip to Lookout Mountain, immediately afterwards.

F. C. DUGAN,
Secretary-Treasurer.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Guniting Methods and Experiences at Cambridge Reservoir. CHAS. E. PRICE. Eng. News-Rec., 100: 474–7, March 22, 1928. Data given which were obtained during repair of Payson Park Reservoir, Cambridge, Mass. Reservoir consists of 2 basins having capacity of 43 million gallons, and was built thirty years ago. Floor is of concrete and slopes are brick and granite. Total area covered was 373,383 square feet, including floor, slopes and division wall, and average thickness of gunite layer was 2 inches. Time required to complete work was 107 days, including Sundays and holidays. Experience in operation of continuous mixer is outlined. Nozzle velocity corresponding to air pressure at gun of not less than 35 pounds per square inch is required to produce hard, dense gunite. None but experienced gunmen and nozzlemen should be employed. With mix of 1:2.5, daily average number of square feet of gunite (2 inch) produced per bag of cement was 11.3, maximum 13.7 and minimum 9.8. Time lost due to repairs, etc., for the 4 guns varied from 31 to 44.6 per cent. This is excessive and should not exceed 10 per cent. Increase in moisture content of sand decreases output. Sand moisture should be less than 10 per cent. Loss of sand in shooting slopes was 12 to 15 per cent, and on perpendicular wall 25 per cent. Shooting into water is unsatisfactory as product does not approximate proper density. Working at freezing temperatures is too expensive and progress is slow. The gunite should be cured by covering with burlap kept wet for at least ninety-six hours.—*R. E. Thompson.*

Desilting Irrigation Canals. Eng. News-Rec., 100: 778, May 17, 1928. Brief data on practice in Imperial Valley Irrigation District, which consists of allowing canal to change its grade wherever possible so that resulting increase in velocity will suffice to carry most of silt through laterals either to sluiceways or on to land. This has been found to be much less costly than trying to maintain flatter grade by dredging.—*R. E. Thompson.*

Designing a High Storage Dam for the Mokelumne Project. F. W. HANNA. Eng. News-Rec., 100: 444–6, May 15, 1928. I. Governing Features of Design

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

of 360-foot Gravity Dam. As part of Mokelumne River project for present mountain water supply of 60 m.g.d. and ultimate 200-m.g.d. supply, East Bay Municipal Utility District is building Pardee reservoir, of 213,000-acre-foot capacity, on Mokelumne River in foothills of Sierra Nevada Mountains near Lancha Plana, Cal. Surface inspection indicated sound rock, and concrete arch dam was therefore considered most suitable. Further exploration indicated conditions which rendered this type undesirable and structure was redesigned as gravity dam curved on 1200-foot radius. Vertical radial contraction joints will be provided at 50-foot intervals. At distance of 5 feet from upstream face these joints will contain annealed copper water stops extending in continuous sheets from bottom to top of dam. **II. Analysis of Concrete Arch Dams.** Methods of designing arch dams are described.—*R. E. Thompson.*

High Earth Dam Threatened by Washout. Eng. News-Rec., 100: 750–1, May 10, 1928. On May 4 a new storage dam of Greenville, S. C., water works developed sudden washout of downstream toe in highest section just above 42-inch cast iron drainage pipe passing through dam at stream level, and immediate failure threatened. Dam, which forms 9-billion gallon reservoir, was constructed in valley of South Saluda River in 1925–27 to supplement present Paris Mountain supply of Greenville and environs. It is rolled-fill embankment containing 600,000 cubic yards of earth, crest height being 140 feet above original river level.—*R. E. Thompson.*

Studies on Prevention of Scour Below Overfall Dams. G. GALE DIXON. Eng. News-Rec., 100: 696–8, May 3, 1928. Results presented briefly of detailed studies which led to selection of spillway section of massive concrete ogee type, with inclined apron so designed as to cause hydraulic jump to occur upon it, for Mineral Ridge dam of Mahoning Valley Sanitary District. Bibliography is given of previous studies on prevention of scour, and the several types of spillways with their relative costs, advantages and disadvantages are compared as applied to Mineral ridge dam, showing merits of inclined apron for producing controlled hydraulic jump. Dam is proposed in connection with development of water supply for Youngstown and Niles, O.—*R. E. Thompson.*

Slumps Complicate Garza Dam Construction. J. C. NAGLE and T. C. SHULER. Eng. News-Rec., 100: 772–5, May 17, 1928. Garza dam for Dallas, Tex., water works is an earth embankment bisected by concrete spillway section. Main dam has crest length of about 11,000 feet, concrete spillway and abutments constituting 550 feet. During construction serious slides developed in part of embankment, necessitating change in cross-section, adding to volume of fill, which was placed hydraulically.—*R. E. Thompson.*

Concreting the Toltec Dam, Zuni Mts., New Mexico. A. F. SCHRAMM. Eng. News-Rec., 100: 631–3, April 19, 1928. Illustrated description of construction of Bluewater Toltec Irrigation District dam in 1926–7. Dam is concrete arch of usual section, with gravity-section concrete abutment at one

end. It is 78 feet high above stream bed and 500 feet long on crest. Reservoir has capacity of 55,000 acre-feet and will impound snow water. Details are included of concrete mix design and methods of placing concrete in winter. —*R. E. Thompson.*

Constant-Angle Arch Dams with Straight Gravity Abutments. Fredrik Vogt. Eng. News-Rec., **100**: 707, May 3, 1928. Brief discussion.—*R. E. Thompson.*

California Water Chlorination Survey Shows Steady Growth. C. G. Gillespie. Eng. News-Rec., **100**: 847, 1928. Chlorination was first practised in California in 1915 at 7 plants supplying a total of 41 million gallons per day. On January 1, 1928, 68 water works, supplying 107 communities with aggregate population of 3,185,000, employed chlorination, the total volume treated being 470 million gallons per day. The total number of water works in the state is 662, supplying 4,340,000 people. Number of works adopting chlorination each year averaged 4.7 for the eleven-years, 1915–25, 8 for three years, 1924–7, and in 1927 alone 16 began chlorination. Of the 68 works, 29 have bacteriological laboratories, and of these 13 make *B. coli* tests and 16 only agar counts.—*R. E. Thompson (Courtesy Chem. Abst.).*

Compressed Air Blows Top Off Pneumatic Caisson. Eng. News-Rec., **100**: 698, May 3, 1928. Brief details given from Home Office Report 1853 (England) on failure of pneumatic caisson for tunnel shaft being sunk at Deptford Green, London, England, in January 1927, which resulted in loss of 5 lives. Shaft was being sunk in connection with intake tunnel for London Power Company Ltd., generating station.—*R. E. Thompson.*

Radial of Parallel Slices in Analyzing Curved Dams. Eng. News-Rec., **100**: 707, May 3, 1928. Discussions, by B. F. Jakobsen and F. W. Hanna, of analysis of arched gravity dams.—*R. E. Thompson.*

Concrete Skeleton Tetrahedrons Prevent Bank Erosion During Floods. Eng. News-Rec., **100**: 752–3, May 10, 1928. Brief illustrated description of method of preventing erosion employed on Santa Clara River near Montalvo, Cal., consisting of row of concrete tetrahedrons made up of 6 legs, 12 inches square and 16 feet long, spaced 3 feet apart. Cost of tetrahedrons was $112 each and total cost of protection work was a little less than $7 per foot.—*R. E. Thompson.*

Iron Removal Plant for Water Supply of Albuquerque, N. M. N. T. Veatch, Jr. Eng. News-Rec., **100**: 845–6, 1928. The water supply of Albuquerque is derived from wells intercepting the underflow of the Rio Grande River, the composite water having the following approximate characteristics: CO_2, 6 p.p.m.; FeO, 5 p.p.m.; temporary and permanent hardness 200 and 100 p.p.m. respectively. The consumption averages 1.8 million gallons per day, with maximum rate of 2.7 million gallons. A 5-million gallon per day Fe removal plant is being constructed consisting of a lime-mixing tank, settling basin,

alum-mixing tank, and 2 filters. The mixing tanks are circular, with tangential inlets and hopper bottoms, detention period being ten minutes. Mixing is effected by the motion of the water through the tank. The settling tank is 15 feet deep and has capacity equivalent to one and one-half hours flow. The filter will be operated at twice the normal rate, functioning principally as roughing filters. The effluent will be chlorinated.—*R. E. Thompson* (*Courtesy Chem. Absts.*).

New Flood Records for California Streams. F. E. BONNER. Eng. News-Rec., **100**: 776, May 17, 1928. Six-day storm of great intensity produced new flood flow records for number of high watersheds in central portion of California's mountain district during latter part of March, 1928. Tabulation given summarizes preliminary records so far obtainable.—*R. E. Thompson.*

Safety Seals for Illinois Waters. Eng. News-Rec., **100**: 867, May 31, 1928. Decalcomania transfers will be employed for marking safe semi-public water supplies in Illinois during season 1928. Lead seals fastened to pumps with copper wire were formerly employed but many of these were stolen.—*R. E. Thompson.*

Stone-Fly Larvae Cause Corrosion of Steel in Running Water. J. B. NAEUMANN. Eng. News-Rec., **100**: 946, 1928. A description of rust nodules found on parts of power plants in Norway submerged in water in motion, which on examination were found to contain the larvae of the stone-fly, *Hydropsychida.* Data given were obtained from an article by N. KOLBENSTVEDT in Elektroteknisk Tidskrift, February 11, 1928 (see following abstract).—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Stone-Fly Larvae and the Corrosion of Steel in Running Water. GERARD H. MATTHES. Eng. News-Rec., **101**: 144, July 26, 1928. During repairs to hydro-electric plant of Colorado Power Co., author found stone-fly larvae in large numbers clinging to rusty steel bars. In all instances the larvae were surrounded by rust scales. The larvae were particularly abundant wherever the water flow was normally swift, and then only on unpainted steel that had been submerged for a long time (cf. previous abstract).—*R. E. Thompson* (*Courtesy Chem. Absts.*).

Runoff Figures in Vermont Flood Reach High Values. H. B. KINNISON. Eng. News-Rec., **100**: 890–1, June 7, 1928. Freshets of considerable magnitude occur rather frequently in New England in spring; but destructive floods so seldom that possibility of flood so great as that of November, 1927, had never been considered. The ordinary spring freshet discharges 15 to 30 second-feet per square mile for small drainage areas. Maximum for ten-year period has seldom reached more than 50 second-feet per square mile. Flood flows of November, 1927, reached maximum of well over 100 second-feet and several determinations show 300–500 second-feet per square mile. Data for several streams, notably the Winooski River, given.—*R. E. Thompson.*

Device for Collecting Deep Water Samples. Edward S. Hopkins. Eng. News-Rec., 100: 870, 1928. Brief illustrated description of sampling apparatus for water depths of 10 to 60 feet, which may be operated from height of 20 to 80 feet above water level.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Water Control in Excavating a Dam Foundation. W. W. Grubber. Eng. News-Rec., 100: 892–4, June 7, 1928. Illustrated description of construction of dam for Mount Union, Pa., water supply, located 6 miles south of town in mountain gap just below junction of 2 streams draining about 3.8 square miles. It will form 25-million gallon reservoir. Dam is of hollow type, of reinforced concrete, with deck supported by buttresses 18 feet on centers. It has maximum height of 44 feet and crest length of 325 feet, and was designed for future extension. Buttresses vary in thickness from 21 to 14 inches and deck slab from 41½ to 24 inches at different elevations. Grouting and temporary drainage were required to extent unusual in small dam construction owing to springs encountered.—*R. E. Thompson.*

Experimental Water Filtration Plant for Chicago. Loran D. Gayton. Eng. News-Rec., 100: 861–3, 1928. A description of the elaborate experimental filter plant recently constructed at Chicago at cost of $150,000. The plant, which includes chemical solution tanks and mixing basins of different types, coagulation and settling basins, and 12 mechanical filters of total capacity of 0.75 million gallons per day, was built to determine the most efficient and economical method of purifying the entire water supply of Chicago, now drawn from Lake Michigan at the rate of 875 million gallons per day and treated by chlorination only.—*R. E. Thompson* (*Courtesy Chem. Absts.*).

Graphics of Temporary Flood Storage. Raymond A. Hill. Eng. News-Rec., 100: 657–9, April 26, 1928. Graphical method described, developed by author, for calculation of balance between reservoir inflow and outflow during floods (see following abstract).—*R. E. Thompson.*

Temporary Flood Storage Calculated by Analytical Method. Melvin D. Casler. Eng. News-Rec., 100: 789, May 17, 1928. Presentation of analytical solution of problem as compared with graphical method of R. A. Hill (cf. previous abstract). Former is considered shorter, simpler, and more direct and accurate than any possible graphical solution.—*R. E. Thompson.*

Débris Openings Built in Spillway of California Dam. Eng. News-Rec., 100: 778, May 17, 1928. Concrete dam completed recently on Bear River for Camp Far West Irrigation District was designed with gravity section arched in plan and has maximum height of 76 feet. Total crest length is 372 feet, of which 150 feet is overpour spillway. Six 7 by 12-foot sluiceways with structural steel sliding gates were provided for passing sand and gravel brought down by high river stages.—*R. E. Thompson.*

Accuracy of Stream Flow Measurements. Kendall K. Hoyt. Eng. News-Rec., 101: 167–8, 1928. Data are given which show that the Price

current meter, when employed by experienced personnel, gives consistent results under different channel conditions, and that it checks with the much-praised Gibson method. Records cited are shown to be more than sufficiently accurate for their purpose. Stated cases strengthen belief that records of river discharge collected under standard methods may be used with confidence.—*R. E. Thompson.*

Spillway of Boyds Corners Dam to be Lowered. Eng. News-Rec., **101**: 176–7, August 2, 1928. Studies of safety of 7 impounding dams built more than twenty-five years ago in Croton watershed have resulted in steps being taken to lower by 15 feet the spillway of Boyds Corners Dam, a masonry-faced structure, backed with earth, put into use in 1872. Dam has maximum height of 78 feet, extreme water depth of 60 feet, and impounds a little over 2700 million gallons of water. Extracts given from report of Wm. W. Brush, Chief Engineer, to J. J. Dietz, Commissioner of Water Supply, New York City, dated July 23.—*R. E. Thompson.*

Difficult Sewer Construction in Wet Ground. H. G. Wray. Eng. News-Rec., **101**: 173–6, August 2, 1928. Deep trenching in water-bearing ground adjacent to small lake required unusual methods of handling water during construction of 4½-mile sewer at South Bend, Ind. Complete emptying of lake (50 to 60 million gallons), and deep sump and well-point pumping of 4,000 to 5,000 gallons per minute barely kept water down so that, with pipe-laying shield and steel-sheeted trenches, construction could go ahead. Methods employed are described.—*R. E. Thompson.*

Remodeling a Small Water Purification Plant. James L. Barron. Eng. News-Rec., **100**: 867–8, 1928. The water supply of Burlingame, Kans., derived from an impounding reservoir on Dragoon Creek, has been treated since 1916 in a plant consisting of an alum solution tank, coagulation basin, and rapid sand filter. The plant has been recently remodeled and improved by addition of a cascade aërator, mixing flume, basin stifling baffle, and machines for applying alum, lime, and Cl_2.—*R. E. Thompson (Courtesy Chem. Abst.).*

Expansion Joints in Wilson Dam Sealed by Asphalt Grouting. Hans Passburg. Eng. News-Rec., **100**: 627–9, April 19, 1928. As pool elevation above Wilson dam was raised during fall of 1924 it was noticed in inspection tunnel that water was leaking through some of the 115 vertical expansion and construction joints in spillway and powerhouse sections of dam. Tar paper was installed in all expansion joints during construction but owing to contraction being concentrated at a few places instead of being uniform at all joints, gaps at many places were too large to be effectively sealed by this means. It was decided to seal expansion joints with asphalt grouting by method developed by G. W. Christians, consisting of pumping hot asphalt through pipe in center of which is an iron wire insulated from pipe and heated by electric current. During latter part of 1926, 115 well holes 6 inches in diameter were put down, one at each expansion joint, the maximum and minimum depths

being 138 and 73 feet respectively, and asphalt grouting applied. Total of 154,000 pounds of asphalt was used. Work was very successful, leakage being greatly restricted. Cost was $4.94 and $5.28 per foot of hole in spillway and power house sections respectively.—*R. E. Thompson.*

Safe-Water Signs in Michigan. Eng. News-Rec., **100**: 942–3, June 14, 1928. Safe-water signs used by Michigan Department of Health for roadside water supplies are described and illustrated. Of 1196 sources tested in 1927, 83.6 per cent were found safe and 16.4 per cent unsafe, a marked improvement over two previous years.—*R. E. Thompson.*

Starting Washed Filters. August V. Graf. Eng. News-Rec., **100**: 867, 1928. Newly washed filters at St. Louis plant are put in service at rate of 0.5 million gallons per day and allowed to run for one hour before rate is increased to that of the other filters. A great number of tests have shown that the turbidity of the effluent is lower with this method than when filter is started at normal rate. When the rate is increased to normal an increase in turbidity occurs, but the maximum is less than one-third of that when filter is placed immediately in service at full rate. At the new Howard Bend plant being constructed on the Missouri River a new device will be employed which will slowly increase rate of filtration from zero to the desired rate in any period of time up to one hour.—*R. E. Thompson (Courtesy Chem. Abst.).*

Mixing Chambers Being Added to Hannibal Filter Plant. Eng. News-Rec., **100**: 849, May 31, 1928. Mixing basins are being added at Hannibal to provide additional time for chemical reactions. At present, water from primary settling basins passes through hydraulic jump mixing flume into coagulation basin. As this arrangement does not provide sufficient time for complete reaction, 2 mixing chambers of conventional type are being constructed between flume and coagulation basins, in which water will flow over, under and around wooden baffles so as to give ten minutes' mixing period with velocity of 0.2 second-feet at maximum plant capacity of 6 million gallons per day.—*R. E. Thompson.*

Turbine Pumping Units for Lake Youngs Chlorination at Seattle. Eng. News-Rec., **100**: 868–9, May 31, 1928. In planning method of applying chlorine in 3 water supply mains (48-, 60- and 66-inch) leading from Lake Youngs storage reservoir, recently completed for Seattle, Wash., source of water pressure decided upon was centrifugal pumps direct-connected to hydraulic turbines operated by water pressure from low point in new mains near control works.—*R. E. Thompson.*

Brass in Engineering: Failures and Remedies. W. N. Jones. Eng. News-Rec., **101**: 161–4, 1928. A detailed description and discussion of failures of brass and bronze strainer plates and bolts in the Minneapolis, Minn., rapid sand filters, together with an outline of similar experiences at other plants. The studies carried out indicated that the failures were due to internal stress set up by cold working of the metal, and subsequent corrosion by external

agencies, such as CO_2. Annealing the metal was found to be an effective remedy, 1300°F. being the critical temperature. Monel metal was found satisfactory.—*R. E. Thompson (Courtesy Chem. Abst.).*

Design of the Owyhee Irrigation Dam. J. L. Savage. Eng. News-Rec., 100: 663–7, April 26, 1928. Details of design given of storage reservoir of 1,120,000 acre-feet (available capacity 715,000 acre-feet) to be constructed by Bureau of Reclamation. Dam is to be built of concrete, of combined arch-and-gravity type, 390 feet high above general foundation elevation, 405 feet high at maximum section and 520 feet high above lowest concrete in foundation cutoff. Power will be developed from water which has to pass dam for prior-right use. Nearly \$100,000 has been expended during past three years on geological and engineering investigations.—*R. E. Thompson.*

Water Works Extension Program at South Bend. Eng. News-Rec., 100: 849, May 31, 1928. Water supply of South Bend, Ind., will be increased during 1928 by sinking of 3 more wells and providing additional pumping plant. Next year a 0.25-million gallon elevated tank will be built to provide better service for section of city 100 feet above general level. Later, it is planned to build 6-million gallon reservoir into which pumps will deliver and which will provide gravity service instead of direct pumping. Total cost of improvements will be about \$500,000.—*R. E. Thompson.*

Comparative Strength of Concrete Pavement Cured by Three Methods. Searcy D. Slack. State Highway Dept., Augusta, Ga. Eng. News-Rec., 101: 170, 1928. The average compressive strengths at 210 days of concrete pavements cured with earth-and-water, Na silicate, and $CaCl_2$, were 4089, 3906, and 3872 pounds per square inch, respectively. The average slab lengths after six months, determined by dividing the total length of the section by the number of cracks plus the number of joints, were 78, 62.9, and 63.4 feet, respectively. The curing methods consisted of (1) covering with 2 inches of earth kept moist for ten days, removing covering after fifteen to twenty days; (2) covering with flake $CaCl_2$, using 2½ pounds per square yard; (3) treating surface with Na silicate, using 1 pound (42.5° Bé.) per square yard. The Na silicate was diluted with water, 3:1, to facilitate covering of the surface. No difference in surface texture could be detected by rough tests.—*R. E. Thompson (Courtesy Chem. Abst.).*

City With High Typhoid Rate Will Not Purify Water. Eng. News-Rec., 100: 846–7, May 31, 1928. Although water supply of Rhinelander, Wis., drawn from Wisconsin River, is polluted, the situation cannot be improved owing to apathy of public opinion which results in continual defeat of bond issues for water works. Propositions were defeated in 1920, 1924, and again in April, 1928. Water is highly colored and turbid. Chlorinating equipment was installed in 1920 but operation is not continuous. Diagram is given showing typhoid case and death rate for Rhinelander and for State of Wisconsin, latter being much lower. A 9-million gallon filter plant installed by Rhinelander Paper Company in 1927 removes 70 per cent of color with 2 grains of alum per gallon.—*R. E. Thompson.*

St. Louis Reconditions Old Sewers with Gunite. E. Paffrath. Eng. News-Rec., 100: 936–7, June 14, 1928. Data given on extensive guniting of sewers being carried out in St. Louis, together with outline of operating experiences.—*R. E. Thompson.*

Twenty Years as a Water Commissioner in a New England Town. Chas. W. Sherman. Eng. News-Rec., 100: 848–9, May 31, 1928. Data given on operation of Belmont, Mass., water supply system during past twenty years. Town, which is 7 miles from Boston, has obtained its supply from Metropolitan water works since inception of Metropolitan District in 1898. Area of town is 4.6 square miles and population about 18,000. All water is supplied through meters. There are 51 miles of main pipes and 3500 services. Construction cost has been in excess of $500,000 and water debt is about $185,000. Annual revenue is $85,000. Total cost of Metropolitan water for each year is computed by state treasurer, including operating costs, bond interest and retirement charges, and this sum is assessed to communities, two-thirds in proportion to consumption and one-third in proportion to valuation. Average cost to Belmont at present time is $70 per million gallons. About 75 per cent of consumption is accounted for by customers' meters. Meters are removed and cleaned at least once in six years. Meters are read every two months and bills rendered semi-annually. During past five years only de Lavaud centrifugally cast pipe has been laid. This pipe is more susceptible to injury by rough handling than sand cast pipe, but after paying for all breaks the saving in cost as compared with sand cast pipe is substantial. Pipe is lined with cement to prevent tuberculation. Joints are usually made with leadite or lead hydrotite. Cement-lined wrought iron pipe is used for most services, couplings and fittings being also lined. Galvanized wrought iron was found unsatisfactory. Service pipes are lined by maintenance men at less cost than commercial cement-lined pipe. Mains are all 6 inches or larger, except temporary domestic supply lines, for which 2-inch galvanized wrought iron pipe is employed.—*R. E. Thompson.*

Water Supplies in Wisconsin. Eng. News-Rec., 101: 168, August 2, 1928. Of 274 public water supplies (exclusive of fire protection) in Wisconsin, 33 are derived from surface sources, 73 from shallow wells, and 168 from deep wells. Program of State Board of Health provides for examination of such supplies once in one, two, or three years respectively.—*R. E. Thompson.*

Local Company to Finance New Municipal Water Supply. Eng. News-Rec., 100: 847, May 31, 1928. New supply is proposed for Bloomington, Ill., city of 30,000 people. Present supply from wells in glacial drift is adequate in quantity but is very hard, total hardness being 800 p.p.m., half of which is sulfate hardness. Plan proposed is to build storage reservoir on Money Creek, branch of Mackinaw River, about 13 miles north of Bloomington, filter and soften the water and deliver it to present city reservoir. Work involves earth dam, 1500-million gallon reservoir, and 14 miles of 24-inch pipe. It is planned to reduce hardness from about 250 to 100 p.p.m. As estimated cost ($1,200,000) exceeds city's bonding limit, method of financing by organization of local

company (Citizens Water Supply, Inc.) has been developed similar to that employed at Decatur, Ill. (Eng. News-Rec., February 17, 1921, p. 299). Plan is to pay off cost within thirty years by increased water rates, whereupon plant will become city property.—*R. E. Thompson.*

Lowering a 400.000-Gallon Elevated Tank. ELDON S. CLARK. Eng. News-Rec., 100: 869, May 31, 1928. Brief description of dismantling and re-erection of elevated tank built at Quincy, Mass., in 1914, which seldom filled to more than one-third of depth. Tank is 40 feet in diameter, 30 feet deep in cylindrical portion, with hemispherical bottom, supported on 8 columns, made up of 3 panels each about 33 feet high. In re-erection, middle sections of columns were omitted. It was necessary to replace roof, roof beams, circular girder supporting roof, and 2 top courses of tank plates. All plates above lower third of tank were badly pitted, particularly next to calking edge of lapping plate. Protection afforded by proper painting was clearly demonstrated, tower being practically undamaged by rust and outside of tank showing very little deterioration. Copper-bearing steel was used in new roof, since difficulty of painting under side is considerable. Cost, exclusive of new steel, was $13,500.—*R. E. Thompson.*

Additional Water Supply for Manila, P. I. PAUL W. MACK. Eng. News-Rec., 100: 841–2, May 31, 1928. Manila and 3 small suburbs form Manila Metropolitan Water District, population of which is 363,000. Average consumption is 23 million gallons per day. Although 100 per cent metered, 35 per cent of consumption is unaccounted for. Meter rate is 9½ cents per 1000 gallons, but users with sewer connection pay 4½ cents additional. There are 123 miles of mains and 21,400 services. Present supply is obtained from Montalban River. Principal features of supply, completed in 1910 at cost of $2,500,000, are masonry dam, 10 miles 42-inch steel pipe siphon, 5 miles 58 by 58-inch grade tunnel and 50-million gallon distributing reservoir. Capacity of aqueduct is 23 million gallons per day. From January to May flow of river drops to 3 to 10 million gallons per day and old Santolan system has to be put into service. New supply from Angat River is being developed, new aqueduct being now under construction to a junction with Montalban aqueduct. Higher head of water delivered at this junction will increase capacity of Montalban aqueduct from 23 to 39 million gallons per day. When consumption increases to latter amount, new aqueduct will be extended parallel to present one. Minimum recorded discharge of Angat River is 80 million gallons per day, and tunnel and cut-and-cover section of new aqueduct will carry that quantity. Angat diversion dam will be 35 feet high, of cyclopean masonry gravity section. Rapid sand filters are provided for in duplicate sets of units of 40 million gallons per day each. One set is under construction and other will be built when consumption demands it. To increase supply as soon as possible, the Novaliches dam was appended to Angat project. It is an earth dam, 95 feet high, on small stream 3.8 miles from junction of aqueducts. Total work under construction, including extensions to distribution and sewage systems, will cost $8,500,000—*R. E. Thompson.*

Removing Iron from Drinking Water. A. Battige. Apparatebau, 39: 306-8, 1927. From Chem. Abst., 22: 1000, March 10, 1928. Aëration in coke-filled towers and filtering through sand is described.—*R. E. Thompson.*

The Sanitary Control of Swimming Pools. Francis E. Fronczak. Jour. Amer. Assoc. Promoting Hygiene and Public Baths, 10: 33, 1928. The New York State Department of Health has issued orders covering the operation of all public swimming pools in the State. They follow the usual practice in regard to quality of water, diseased persons, suits, showers, prescribe the quantity of fresh water supplied on the basis of the number of bathers, and prohibit spectators from approaching the pool.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

The Twort-D'Herelle Phenomenon. Philip Hadley. Jour. Infectious Diseases, 42: 4, 263, April, 1928. This article is a critical review of the literature on bacteriophage action comprising 161 pages of text and referring to 372 selected articles. In addition, the author reviews his own work and presents a new conception of bacteriophage action termed the homogamic theory.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Bilharzia in Australian Troops. N. Hamilton Fairley. Health, Commonwealth of Australia, 6: 3, 75, May, 1928. In 1915, Lieut.-Col. R. T. L. Leiper proved there were two distinct bilharzic parasites and that the disease was caused by small immature worms (cercariae) which swam about in the sweet water canals and bored their way through the skin of bathers, finding their way to the veins of the liver, intestines and bladder where the worms attain full maturity and mate. The female worms lay their eggs in the internal organs. From time to time the eggs ulcerate through the walls of the bladder and intestine and are passed out in the urine and feces. On reaching water, they hatch out, becoming actively motile organisms known as miracidium. If suitable fresh water snails are present, these small creatures bore their way into the liver of the mollusc and in a period of six weeks result in the production of thousands of immature worms (cercariae). These escape from the snail in search of some suitable host, that is, man. To control the disease in Australia, attempts have been made since 1920 to treat every case among returned soldiers. They were treated either with tartar emetic or emetine hydrochloride.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Scarborough (England) Water Supply. H. Lapworth. Surveyor, 73: 1887, 347, March 23, 1928. A description of an extension of the water supply of this noted seaside resort, designed to provide an additional well supply of 2.6 million gallons, doubling the present supply. The total estimated cost of the extension is £102,150, or about $500,000. The original pumping plant, about forty years old, will be augmented by two vertical turbine pumps. Sand filtration is used on both the old and the new supply.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Important Decision of the Indiana Appellate Court in Reference to Stream Pollution. Monthly Bulletin, Indiana State Board of Health, 31: 6, 85, June, 1928. The Appellate Court of Indiana rendered an opinion on June 19 in the case of City of Frankfort vs. Jay D. Slipher, affirming the judgment of the Circuit Court holding the City of Frankfort liable for damages growing out of the pollution of Prairie Creek by alleged unlawful deposit of sewage therein. The court reviewed the facts and law governing stream pollution considering the appellant's contentions: (1) that a city may pollute a stream so long as such discharge is without negligence; (2) neither evidence nor facts were sufficient to establish public nuisance; (3) certain statutes provided a method by which riparian owner might obtain relief and having failed to avail himself of such statutory remedy plaintiff cannot maintain this action. The court held that the statutes simply give the State Board authority to enforce provisions of the act for public health and are not available to indiviual owners who must seek relief through the courts as did the appellee in the instant case. Concerning contentions (1) and (2) the court said, "The rule of necessity thus declared must in and of itself inevitably force just the opposite doctrine, in the interest of the public health, the very thing supposed to be subserved by the rule, when it is daily becoming more and more apparent that the sewage in the streams is a real menace to the public health, and it is not a necessity, because it can be otherwise provided for, with practicability and assured safety to the public health. Far preferable and more consistent, both with private rights and the public interest, that the streams shall be preserved without contamination, and as arteries adequate to carrying the floods of water, continually increasing in quantity and velocity by reason of the agricultural drainage, precipitating them quickly into streams, and that no supposed rule of necessity in order to the carrying on of a business, on account of its usefulness or necessity, or that it cannot be carried on without producing these results, nor the fact of skill and care to prevent it, or on account of the amount involved, can be allowed as an exception, nor can the riparian owner below be required to protect himself; tho right to an incident of the title, and such is the law of this state."—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Great Lakes Drainage Basin Sanitation Agreement. Monthly Bulletin, Indiana State Board of Health, 31: 6, 87, June, 1928. At a meeting of the State Health Officers of Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania and New York in St. Paul, a resolution was adopted which instructed and authorized the engineers of their respective states to meet and form an organization to proceed with studies and investigations to determine the nature, degree, cause and sources of pollution and recommend plans and methods for interstate cooperation on the part of signatory states. The Chairman of State Health Officers Organization was named ex-officio Chairman of the Board of Engineers.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Rivers Pollution Prevention with Special Reference to the Work of this Association. J. H. Garner. Proc. Assoc. Managers Sewage Disposal Works, Bedford, England, 15 pages, July 8, 1927. This paper reviews the efforts of

the British Government to handle problem of stream pollution and discusses what should be the future activities along these lines. It emphasizes the need of further research solving river problems.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Application of Laboratory Research to the Study of Hydraulic Problems. George H. DeThierry. Jour. Boston Soc. Civ. Eng., 15: 1, 1, January, 1928. The application of hydraulic formulae admits of much error. The most useful discoveries in the hydraulic field were made by those who applied the laboratory method, rather than relying wholely on mathematical formulae. Dr. DeThierry gives a series of illustrations of different engineering problems with a view of giving an idea of the variety of applications of hydraulic laboratory research methods, particularly as practised in the hydraulic laboratories of Germany, Austria, Sweden, Russia, and Czechoslovakia. These cases are admirably illustrated with diagrams and photographs. The laboratory method in general appears to be a duplication of conditions as nearly as possible to those which will be encountered in the field, and to make the tests accordingly. The article describes some interesting European cases, and is well worth reading by those not familiar with this method of hydraulic study. —*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Water Supplies. A. W. Fuchs. Public Health Bulletin No. 164, Municipal Health Department Practice for year 1923, 467, July, 1926. Public Health supplies were privately owned and operated in only 16 of the 100 largest cities of the United States in 1923. In most cities the local or state health department made all laboratory examinations or ran check analyses. Over two-thirds of the cities used surface waters exclusively. Only eight supplies received no treatment, and these were all from wells. Nearly half the cities employed filtration as the major treatment, and 81 supplies were chlorinated either constantly or partially. Technical supervision of treatment was the rule. There were still 11 cities in which less than 90 per cent of the population used the public supply. In six cities the population accessible to the public supply was much greater than that using it.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

An Outbreak of Infectious Diarrhea on Board The U. S. S. "Melville" Attributed to Contamination from Gatun Lake, Canal Zone. Dallas G. Sutton. United States Naval Bulletin, 26: 3, 727, July, 1928. At the time the U. S. S. Melville was in transit through the Panama Canal from Balboa, Canal Zone, to Colon, Panama, in March, 1927, about 6,000 gallons of water from Gatun Lake were taken on board for use in the boilers and stored in the ship's tanks after distillation. The cloudy appearance and unpleasant taste of the water attracted attention, so that samples of the water were collected and cultures made which indicated a heavy pollution of the water with B. coli. At the same time a number of the crew developed symptoms of mild enteritis. Following the isolation of B. coli from the fresh water supply of the ship and the appearance of acute cases of enteritis among the crew, the water was pumped overboard and all tanks cleaned. They were then filled with freshly distilled water

and disinfected by the addition of a solution of chlorinated lime. After this procedure no other cases of enteritis developed at the time. No water was taken on board during the return trip so that water in tank No. A2, to which a later outbreak of acute enteritis was attributed, must have been overlooked when the other tanks were emptied, cleaned and disinfected.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Institution of Water Engineers. Anon. Surveyor, **73**: 1901, 697, June 29, 1928. In 1913 the Torquay Corporation Waterworks was troubled with Synura. Satisfactory removal was attained by the use of copper sulphate in the proportion of one pound per million gallons of water applied in bags drawn behind a motor boat, the action of the propeller serving as an efficient mixing device to distribute the chemical through the water.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Notes on River Pollution and Some of its Effects. C. C. DUNCAN. Jour. Royal Sanitary Institute, **48**: 12, 623, June, 1928. A narrative report of the condition, sources of pollution, and use of rivers in Worcestershire, namely, the Severn, Stour, Avon, Arrow, Salwarpe and Teme. Attention is called to good effects of self-purification aided by aeration at locks and weirs. The rivers are contaminated with domestic sewage, common salt from salt deposits, galvanizing plant liquor, sugar plant wastes, and waste from a sausage skin factory. Treatment is obtained where badly needed. With close attention to filtration most of the streams can be used for water supply but the author calls attention to the expense made necessary by river pollution.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Liquor Effluents from Gas Works. A. PARKER. Water and Water Eng., **30**: 355, 329, July 20, 356, 377, August 20, 357, 414, September 20, 1928. The most important effluents, as regards difficulty of disposal, result from manufacture of ammonium sulfate and other ammonia products from the crude ammoniacal liquor. The effluents arising from the manufacture of sulphate of ammonia are: (*a*) spent liquor from still (residual); (*b*) "Devil" liquor, the condensed distillate after ammonia has been absorbed from still vapor by passage through dilute sulfuric acid. The works effluent is usually made up of 85 to 90 per cent *a* and 10 to 15 per cent *b*. The principal abnoxious constituents of the effluent liquors are phenols, higher tar acids, salts containing sulfur and salts containing cyanogen. Analyses are given showing the concentrations of these substances in ammoniacal liquors from horizontal and vertical retorts, and the composition of the corresponding effluents are calculated on the basis that 100 volumes of ammoniacal liquor give rise to 150 volumes of effluent. The composition of the spent liquor from the still and of the "devil" liquor are also given. The spent liquor is usually brown in color and turbid with particles of spent lime and tarry matters. Most of the lime settles readily, leaving a liquid possessing a high affinity for oxygen. **Effect on Streams and Sewage Purification.** A discharge of this type renders water poisonous to fish and cattle and unfit for ordinary use, and its high oxygen-absorbed values of strong, average and weak sewage are calculated. Methods

proposed for reducing or eliminating difficulties in disposal of effluents are classified as follows: (*a*) modifications in practice to reduce volume of spent liquor; (*b*) modifications in practice to improve the composition of spent liquor; (*c*) methods proposed for the purification or disposal of spent gas liquor. The volume of ammoniacal liquor, and therefore of the spent liquor, depends on the coal moisture, the water formed during carbonization, and the amount of water applied to the scrubbers. With steamed vertical retorts, the volume is augmented by the steam which passes through the retorts without being decomposed. An excellent review of the literature dealing with the disposal of spent liquor is given. It has been found at many plants that the liquor can be disposed of by treatment with domestic sewage, but, although the volume of waste is usually only approximately 1 per cent of the total volume of sewage, an appreciable increase in purifying area is necessary owing to the high oxygen-consuming power of the liquor.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Brief History of Sewage and Waste Disposal. H. B. Hommon. Pacific Municipalities. **42**: 5, 161, May, 1928. This interesting article gives a short account of the history of sewage and waste disposal in Europe and the United States. In 1855 just after the cholera epidemic in England, a "Nuisance Removal Act" was passed. In 1857 the "Royal Sewage Commission" was appointed to determine methods of safeguarding river pollution. This commission created sufficient interest in sewage disposal to bring about the appointment of the "Royal Commission on River Pollution" in 1865. This Commission was directed to determine whether or not the restrictions of sewage into water courses would result in other serious conditions. The Commission was unable to come to a definite conclusion but functioned until 1870, when the biological process of sewage treatment was developed. Prior to 1870 both France and Germany had attempted sewage treatment, but with little success. After 1870 rapid progress was made in sewage disposal in Europe. The first study of sewage disposal in the United States was made by the State Board of Health of Massachusetts in 1872. Little was accomplished, however, prior to the establishment of the Lawrence Experiment Station in 1888. Shortly after that several cities made studies of sewage and waste disposal. Several instances were cited where the industries are now coöperating with State Boards of Health to solve waste disposal problems.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Iodine in Drinking Waters. J. B. Orr, W. Godden and J. M. Dundas. J. of Hyg., 1928, **27**: 197–9. Bull. of Hyg., **3**: 772, September, 1928. Analyses of samples of drinking water from various parts of the British Isles have shown that the amount of iodine in any particular sample can not be correlated with the goitre incidence in the district from which that water sample came. During the processes of filtration, no loss of iodine was found to occur, but softening by Clark's process caused a loss of one-half the iodine.—*Arthur P. Miller.*

An Enquiry into Methods for the Purification and Disposal of Waste Waters. G. A. Park Ross and L. F. DeFroberville. Internat. Sugar J., 1928, July, 376–82. Bull. Hyg., 3: 752–753, September, 1928. The growing nuisance from sugar factories in South Africa of late has led the Ministry of Health to send an observer to Europe to undertake inquiries into the methods of waste disposal from similar factories there. The authors, in the review of their findings, give much valuable information concerning the disposal of wastes from both beet and cane sugar factories. As to the application of European principles to South Africa, they conclude: (1) In the hilly country of the sugar cane belt and where there is a scarcity of water the best way to handle the wastes is to get out all impurities in the form of mud and cake so that they can be handled as solids and to recover the water for reuse after purification. (2) Volume of waste waters should be minimized by restricting the use of clean water and they should then be subjected to treatment with carbonic acid, obtaining thereby a heavy precipitate of calcium carbonate which will carry down suspended and colloidal matters leaving only sugar in solution. (3) Chemical precipitation by means of ferrous sulphate and lime is also recommended for treating waste waters prior to reuse. Some work in this direction has already been undertaken in South Africa.—*Arthur P. Miller.*

The Treatment of Beet Sugar Factory Effluents. O. Spengler. Surveyor, 1928, 73: 323–5, Bull. Hyg., 3: 754, September, 1928. This author advises separate treatment of the wastes produced in beet sugar factories. In Germany the fluming and beet washing water is usually mechanically clarified, kept in circulation, and reused. Two recent processes for disposing of the pulp-press water and the diffusion water are: (1) The double fermentation process. (2) The fermentation and putrefaction process. The former process is carefully described, but the latter is not so clearly stated.—*Arthur P. Miller.*

On the Toxicity to Animals of Alkaline Effluents. L. Hugounenq, A. Morel and A. Jung. Ann. d'Hyg. Pub. Indust. et Sociale, 1928, 6: 43–9. Bull. Hyg., 3: 754–755, September, 1928. In recovering tin and iron from old tin cans, etc., there was used a process of electrolysis in a tank containing 6 to 7 per cent NaOH. The iron was washed in another tank the water in which became more and more alkaline until eventually released to a river. At low summer levels, this alkaline waste killed fish for a distance of several kilometres below the factory and animals which drank of the water were stricken with severe diarrhœa. Analysis of the water showed that it contained 0.040 gram of caustic soda and 0.212 gram of bicarbonate of soda per litre. There were also small quantities of tin, lead, and sodium stannate present. The authors consider that alkaline trade wastes are just as important as acid ones, from the stream pollution standpoint.—*Arthur P. Miller.*

The Relation of Endemic Goitre to the Iodine-Content of Soil and Drinking-Water. R. McCarrison, C. Newcomb, B. Viswanath, and R. V. Norris. Indian J. M. Res., 1927, 15: 207–46. Bull. Hyg., 3: 771, September, 1928.

Samples of soil, water, and salt from certain districts in India were examined for iodine content to ascertain if there was any correlation between those results and the incidence of goitre among the natives. Goitre is less common in the iodine-rich localities of Southern India than in the iodine-poor section of Himalayan India; but otherwise no relationship between iodine content of soil and water and goitre incidence was found to exist. The main conclusion reached was that the essential cause of endemic goitre in Himalayan India is to be found in the unhygienic living conditions and particularly the impure water supplies. Under these conditions, iodine deficiency favors the development of the disease even though it may not determine it.—*Arthur P. Miller.*

Endemic Goiter in Oregon. R. OLESEN. Pub. Health Rep., Wash. 1927, 42: 2831–49. From Bull. Hyg., 3: 767. September, 1928. A thyroid survey in Oregon of 17,608 children showed 30.9 per cent to have thyroid enlargements. The incidence is less at sea coast towns than further inland, but that does not mean that proximity to the ocean confers immunity. Analyses of drinking water have yielded low iodine content. In no district having high goitre incidence was there any evidence of pollution of the drinking water supply.—*Arthur P. Miller.*

Sheffield's Water Supply. Anon. Water and Water Eng., 30: 358, 451, October 20, 1928. The water supply of Sheffield, England, is a fair example of the soft upland waters generally used by cities in the north of England. Its raw quality is good and such purification as is used is for removing suspended matter and color. Part of the filter plant was built in 1913 to care for 3½ m.g.d. and the new section just opened will handle 4 m.g.d. The new plant includes: (1) Chemical preparing and measuring apparatus. (2) Thirty-two pressure filter units each 8 feet in diameter, giving a total filtering area of 1600 square feet, connected to proper inlet and outlet lines and arranged for cleaning by compressed air. (3) Engine driven rotary blowers for providing compressed air. The chemicals used are alumino-ferric for coagulation and some lime for acid neutralization. Sheffield was the first city in England to overcome the action of moorland water on lead pipes.—*Arthur P. Miller.*

On the Relationship Existing Between Carbonates and pH and Conductivity in Natural Waters. RONALD SENIOR-WHITE. Water and Water Eng., 30: 358, 455, October 20, 1928; Indian Journal of Medical Research, April, 1928. The measurement of carbonate, bicarbonate, and CO_2 involves procedures not easily accomplished in the field, but pH is determinable with some accuracy with apparatus suitable for field use and only small water samples need be returned to the laboratory to determine conductivity. A series of routine water tests by the author has shown close relationship between (1) pH value and the percentage of total carbon dioxide present in "free" and "half-bound" forms and (2) total carbonate, including dissolved free CO_2, and the conductivity as measured by a Kohlrausch bridge and cell. In the case of (1) above, the relationship was so close in the natural waters sampled at random as to permit a calculation, based on the pH, of the percentage of free and half-bound to total carbondioxide present. As to (2) above, the author found that

when only pure water from springs and streams is considered, the correlation was 0.88. This was based on 35 observations only.—*Arthur P. Miller.*

Concrete Pipes. Anon. Water and Water Eng., 30: 358, 456, October 20, 1928. Cement pipes have not always given satisfaction in peaty soils; but their impermeability can be improved by making better concrete. A few rules to accomplish this are given.—*Arthur P. Miller.*

Wooden Aqueduct of the Badian Murg Power Works. Anon. Water and Water Eng., 30: 358, 473, October 20, 1928. An interesting feature of these works is the application of wooden pipe in the crossing of a valley having its sole 48 meters below. The pipe was 1.5 meters in diameter and maintained tightness under 45 meters head at the junction of the wooden pipe with the iron on each side of the valley. Pipe wood is 55 mm. in thickness. Pipe was built on the ground, covered with earth on valley sides, and the wooden lead supported on concrete underwork.—*Arthur P. Miller.*

Protection of Under Ground Pipe from Corrosion. E. O. Slater. Ind. Eng. Chem., 21: 19–21, 1929. This article discusses possible coatings and wrappings for iron and steel pipe and presents a definite method used in different kinds of soil conditions in southern California. It is a paint-paint-wrapping combination, or a paint wrapping-hot bitumen proposition. A thin priming coat of bitumen is applied, followed by a thicker coat of the same material. If excessive protection is desired, cotton wrapping is applied followed by additional coats of the paint. Tests are given to show that such a coating is electrically resistant.—*Edward S. Hopkins.*

Effect of the Addition of Lime and Soda Ash to Brackish Water on the Corrosion of Iron and Steel. H. O. Forrest, J. K. Roberts and B. E. Roetheli. Ind. Eng. Chem., 21: 33–5, 1929. It is believed that the concentration and nature of the dissolved solids, concentration of calcium carbonate, and concentration of retarding agents added in water of brackish nature are the factors which influence the reduction or elimination of the corrosion of iron and steel. Standard 1-inch wrought iron and steel pipe were tested with diluted synthetic sea water to insure constant water composition. The results obtained indicate that (1) a high concentration of calcium bicarbonate salts with a pH of 8.5 or greater will precipitate calcium carbonate as a protective coating on surfaces in brackish water; (2) addition of calcium hydroxide, even in excess, to waters high in bicarbonates, or of sodium carbonate to waters high in calcium salts, will decrease corrosion; (3) large quantities of calcium bicarbonate are necessary to obtain a protective coating as small amounts accelerate corrosion; (4) pH value of all concentrations of sea water with varying bicarbonate content, but with 100 p.p.m. calcium hydroxide, are nearly equal; with lower concentrations of calcium hydroxide, these values decrease as the calcium bicarbonate increases.—*Edward S. Hopkins.*

The Composition and Use of Ferric Hydroxide Floc as a Coagulant. Edw. S. Hopkins. Ind. Eng. Chem., 21: 58–60, 1929. This study was undertaken

to place water plant operation on a more accurate control basis and presents practical operating data governing the use of ferric hydroxide floc (iron and lime coagulation) as a coagulant, together with the pH value for the maximum removal of turbidity therewith, using simulated plant conditions. The maximum economical precipitation value of the floc is at pH 9.4. A simplified method for estimating the amount of turbidity in the coagulating basin after settling of the floc is given. The optimum pH value for turbidity removal by this coagulant has been determined for various concentrations and is approximately pH 9.4, or equivalent to the point of maximum precipitation. The composition of the floc has been studied and is comparable with that of alum floc. A theoretical discussion of the characteristics of sulfate adsorption in ferric hydroxide is given. The experimental procedure is outlined and the data are further explained by means of tables and curves.—*Edward S. Hopkins.*

Report of Investigation and Tests of Inner Linings of Distribution System of Remscheid (Bericht über Untersuchungen und Versuche an der Remscheider Rohrschutzanlage). THIESING and L. W. HAASE, Gas- und Wasserfach, 40, 961 and 41, 988, October 6 and 13, 1928. The city of Remscheid in August, 1926, placed in operation a plant designed by Dir. BUCHER of Wiesbaden, containing equipment for adding calcium hydroxide to the filtered surface water (its regular supply) for the purpose of building up a protective coating on the inner surface of the pipes of the distribution system. Tests were made at fourteen-day intervals from January, 1927, to May, 1928 by the Prussian Institute for Water, Soil, and Air Hygiene at Berlin-Dahlem, of samples secured from different sections of the distribution system. The report sums up, in part, as follows: (1) Water low in chlorides and organic matter may be treated with lime water. (2) In consequence, corrosion is quickly arrested and red water troubles disappear. (3) Protective coating forms as well on zinc and lead as it does on iron. The aggregation is slow enough to be of no practical consequence. (4) Oxygen is necessary for the formation of such protective coating.—*Richard F. Wagner.*

Chemical and Physical Properties of Water Leading to Corrosion and the Prevention of Corrosion (Chemische und Physikalische Eigenschaften des Wassers als Vorbedingung für die Korrosion und den Korrosionschutz). L. W. HAASE, Gas- und Wasserfach, 42, 1010, October 20, 1928. The author in an address delivered in Hamburg at the annual (1928) meeting of the German Association of Gas and Water Engineers, describes in a concise way the accepted theory of the causes of aggressiveness of waters of various analyses and of watery solutions upon currently used pipe materials. The paper closes with a description both of natural and artificial pipe coating processes.—*R. F. Wagner.*

"Water;" an Exhibit at the 1928 Review of German Work at Dresden known as "The City Technical" (Die Sonder-Ausstellung "Das Wasser" auf der 7ten Jahresschau Deutscher Arbeit, Dresden, 1928, Die Technische Stadt). Director VOLLMAR, Dresden, Gas- und Wasserfach, 43, 1046, October 27, 1928. In this paper Director VOLLMAR very fully describes the exhibit of the

sub-group "Water" forming part of a main group "The Life Sources of The Technical City" at the Dresden exposition. The goal desired was to make visitors fully acquainted with the methods and problems of the production, preparation, and distribution of water in a modern water supply system.—*R. F. Wagner*.

Further Experiences in the Field of Chlorination of Domestic Waters (Weitere Erfahrungen auf dem Gebiet der Chlorung des Trinkwassers). HAYO BRUNS, Gas- und Wasserfach, 44, 1057, November 3, 1928. The author, after drawing attention to the close relation existing between the reduction in typhoid fever fatalities and the accompanying increase in chlorination of domestic waters, both in the United States and in Germany, describes the more recent advances in chlorination practice.—*R. F. Wagner*.

Purification of Domestic Water Supplies in North America, Especially the Chlorination Phase Thereof (Trinkwasserreinigung in Nord-Amerika, mit besonderer Berucksichtigung der Chlorung). ORNSTEIN. Gas- und Wasserfach, 45, 1081, November 10, 1928. A description of the sources of supply of the larger cities which, largely surface waters, early led to rapid sand filtration and chlorination. The advantages of pre-chlorination and eventual de-chlorination are cited, as are also the causes of phenol, cresol, and kindred tastes and their removal with the aid of sulphur dioxide.—*R. F. Wagner*.

The Significance of B. Coli in Ground and Spring Supplies (Bedeutung des Kolibefundes bei Grundwasser- und Quellwasserversorgungen). M. NEISSER, Gas- und Wasserfach, 46, 1106, November 17, 1928. The author, after discussing the various varieties of *B. coli*, advocates frequent periodical examination of the individual sources of the central supply for *B. coli*, such examination being greatly simplified by the use of the "Faecal Index" of Dr. GERSBACH. The writer represents that local disturbances frequently are responsible for *B. coli* and that the practice above recommended is more logical than resorting to chlorination of the entire supply upon the first evidence of the presence of *B. coli* in the central supply.—*R. F. Wagner*.

The Water Supply from the Muldental Dam (Die Wasserversorgung aus der Muldentalsperre). Dipl. -Ing. HERZNER. Gas- und Wasserfach, 48, 1161; 49, 1185; 50, 1213; December 1, 8, and 15, 1928. A central source, the Muldental Lake and Dam, placed in service in 1925 and maintained by the State of Saxony, is to supply eventually approximately 150 cities and communities. Methods of financing and apportionment of costs are described as well as distribution system details.—*R. F. Wagner*.

Tuberculation of Cast-Iron Pipe. CHARLES W. SHERMAN. Jour. New England Water Works Assoc., 42: 3, 259–278, September, 1928. Article reproduces reports of investigations by City Engineer of Boston and Prof. E. N. HORSFORD, on the effect of tuberculation upon the carrying capacity of uncoated cast-iron pipes. Efficiency of cement lining to prevent tuberculation was recognized as early as 1835. Two French engineers, VICAT and GUEMARD after

two years of experiments, found that hydraulic cement applied about 0.0984 inch thick combined facility of application and cheapness, adhered best to castings, was most indestructible,.and prevented most effectually all oxidation and consequent formation of tubercles. They recommended interior of mains to be washed over with this composition by means of a sponge. In 1837 the subject attracted the attention of British Association for Advancement of Science. Elaborate investigation of action of air and water (fresh or salt; clear or foul) at various temperatures, upon cast-iron, wrought-iron, and steel, were made by MALLET. He found that any sort of iron when exposed to action of water holding air in combination will exhibit one of the following forms of corrosion: (1) uniform; when whole surface is covered with a coat of rust requiring to be scraped off, leaving smooth red surface under it; (2) uniform, with plumbago; where surface is covered with plumbaginous matter which leaves a piebald surface of red and black after it; (3) local, or only rusted in some places; (4) locally pitted; where metal found unequally removed to greater or less depth; (5) tubercular; when the rust derived from every point of the specimen has become transferred to one or more particular points of its surface forming large projecting tubercles. MALLET was of the opinion that VICAT'S proposed method of coating with hydraulic cement would have but little permanence. First report of Prof. HORSFORD, 1852. Nodules found in pipes were of either a reddish, or a dirty yellow color, each color characterizing a group. When placed in hydrochloric acid, reddish and yellow material dissolved to dark red solution (ferric chloride); and residue, chemically examined, proved to be silica. Difference in color was considered due to unequal heat to which nodules had been exposed. Slight elevations of surface immediately beneath accretions were due to change in texture of iron arising therefrom. In the second report of Prof. HORSFORD, 1853, consideration was given to various agencies operating to promote growth of accretions. Prominent among these is presence of inorganic salts. A striking peculiarity of Cochituate water is its superior capacity for holding air in solution. This, however, is not the most prominent cause for accretion. Rusting is promoted by roughness, purity of metal, and presence of sulphur. Within a few years after these reports were made ANGUS SMITH coal tar coating came into use for cast-iron pipes and was very effective in prevention of tubercles. In early years the quality of coating was better than that now obtainable. Quantity available was greater in proportion to amount of pipe produced. Report by FREDERICK S. HOLLIS (never before published) gives interesting information regarding tuberculation and organic growths in cast-iron pipes laid in 1887 & 1894. Examination of 30-inch pipe laid in 1887 and kept in regular use, showed tubercles and brown slime present. Slime consisted of partly decomposed organic matter with crenothix in small quantities; the infusorian *Acineta* was the organism most abundantly present. Photographs are given depicting tubercles and their characteristics.—*Carl Speer, Jr.*

The Rainfall of New England. Part 2. Seasonal Rainfall. J. HENRY WEBER. Jour. New England Water Works Assoc., **42**: 3, 278–290, September, 1928. New England region has even seasonal distribution of rainfall, but there are considerable differences within bounds of New England states, particularly

between coastal stations and those of the interior. All stations on Southern Massachusetts coast, Connecticut, Rhode Island, and Maine indicate a winter maximum and a summer minimum; in far interior, maximum is in summer, minimum, in winter or spring. Between coast and far interior is region of uniform mean monthly rainfall. In coastal region, means for March and June are 5.1 and 3.1 inches, respectively: in interior region means for February and June are 1.63 and 3.60 inches, respectively: in intermediate region, highest mean, 3.76 inches, occurs in September; lowest, 3.33 inches, in June. Mean seasonal rainfall of southern New England includes: (1) Winter rainfall: which for most of southern New England amounts to 10 to 13 inches. About one-fourth to one-third of winter precipitation in southern area falls as snow: this proportion increases towards the interior, being greatest in the Berkshire Hills. (2) Spring rainfall; the higher rainfall in southern portion being due chiefly to greater precipitation in March. (3) Summer rainfall; greatest occurring in interior, and least on the coast. (4) Autumn rainfall; rather evenly distributed throughout area, and for region as a whole averaging close to 11 inches. **Part 3. Mean Monthly Rainfall of Southern New England.** J. Henry Weber. Ibid., **42**: 3, 291–299, September, 1928. General rainfall distribution throughout Southern portion of New England states for each month in the year. Diagrams showing distribution for each month are given, and also tables showing mean monthly rainfall at all stations in Southern New England.—*Carl Speer, Jr.*

The Water Supply of Caracas, Venezuela, with Notes on Conditions Affecting Water Supplies of the Country. Thorndike Saville. Jour. of New England Water Works Assoc., **42**: 3, 303–335, September, 1928. Total area of Venezuela is 394,000 square miles; population is less than 3,000,000. Water supply of Caracas has two general sources: (1) low-level supply which constitutes about 80 per cent of total comes from Macarao River which has a drainage area of about 34.4 square miles; (2) high-level supply, for extreme northern part of city, which comes from head waters of Catuche and Cotiza creeks, having combined drainage area of 3.8 square mile. *Macarao Supply.* Catchment area above intake is mountainous and is drained by several small streams. Practically all the rainfall occurs in heavy showers lasting about an hour. There is some amount of ground storage in gravel deposits of Macarao Valley, but this is rapidly depleted during dry season, by seepage into the stream and by evaporation. Diagram shows how water is taken from river directly into a rectangular brick canal which discharges into both a cast-iron pipe line and a concrete aqueduct which convey it to Caracas and intermediate points. Two sand traps in the canal are not sufficient to remove all suspended matter. Pipe line, 18 inches in diameter with lead joints, carries about 3.3 m.g.d. In 1916 and 1917 reinforced concrete canal was constructed to replace old open canal: its length is 20.6 miles and it cost $2.10 per lineal foot. Pipe line and aqueduct deliver water to Calvario Reservoir a covered, reinforced concrete reservoir with capacity of 2,500,000 gallons. At a lower elevation is Guarataro Reservoir fed by a branch leading from former. Total storage of the two reservoirs is 3,290,000 gallons, or less than $\frac{1}{3}$ of a day's supply. *Catuche and Cotiza Sources.* Two mountain streams with combined drainage area of 3.8

square miles. Cotiza source, developed in 1917, delivers only 342,000 gallons daily, but has capacity for 770,000 gallons. Combined average yield is 800,000 gallons daily. Additional water supply is needed due to rapid growth in population. It is necessary to investigate amount and distribution of rainfall in Caracas and surrounding region. Tables are given, showing annual rainfall at stations in Caracas and vicinity, daily and monthly rainfall at Caracas Observatory, and distribution of rainfall in (theoretical) normal year and in extreme years arranged on a climatic year basis. Causes of local variations in rainfall are the annual movement and position of "heat equator," and local topography. Results show no definite trend in annual rainfall. *Question of how best to utilize Macarao River for additional supply.* Project is reported on for diversion of two tributaries of the San Pedro River and the Rio Jarillo into the water-shed of the Macarao. It is stated that the former could be diverted by a canal 4.9 miles long, at cost not to exceed $30,000; the latter, by 3.1 miles of canal, pipe-line, and tunnel. These diversions would, however, cause damage to irrigated land; they would not be required if a dam were built on Macarao River, probably the cheapest project. Excess water thus diverted during floods would be all that would then be required to tide over periods of low-water flow. At no time of year would the bacterial character of the water enable it to pass requirements of the United States Public Health Service. It is heavily polluted at least 9 months of the year, and at all times beyond the point where it could be consumed with safety. It has no odor, or objectionable taste, nor does it contain chemical ingredients injurious to health. Only for removal of bacteria and turbidity is treatment required. Slow sand filters are recommended, since cost of operation and amount of skilled attention would be less than with rapid sand filters. Chlorination should be adopted whether filters built or not. Author believes filters would not be necessary if Macarao Reservoir built. Water of Catuche and Cotiza sources is of better bacterial quality than that of the Macarao River, but still not satisfactory because of high bacterial and *B. coli* counts. A unique factor in design and operation of distributing system is practice of delivering water to houses for two or three hours per day only. Each house must have storage tanks to hold a day's supply. Main pipes are 6 to 12 inches in diameter; street mains, 2 to 6 inches. Larger mains are not required, since there are no fire services. Buildings are all of fire-resistant materials.—*Carl Speer, Jr.*

ABSTRACTS, SUB-COMMITTEE NO. 9

JOINT RESEARCH COMMITTEE ON BOILER FEEDWATER STUDIES

The Properties of Materials for Use at High Temperature, with Special Reference to Boilers for Superheated Steam. R. G. C. BATSON. Instn. Civil Engrs., Introductory Notes (Lond.), group 2, 1928, pp. 12–16. Results expected from steels used for boiler and superheated tubes, and superheater and steam drums given in tables; possible to obtain materials that will meet requirements for increased steam pressures and temperatures; involve use of expensive alloys.

Standardization of Methods of Investigating Boiler Feedwater (Vereinheitlichung der Untersuchung von Kesselspeise-waessern und deren Beurteilung). A. Frederking. Waerme (Berlin), 51: 40, October 6, 1928, pp. 724–725. Author gives reasons for standardization and discusses requisites of standard method; reagents and apparatus; measurement unit; standardization of requirements for boiler feedwater.

Classification and Evaluation of Boiler Feedwater According to Modern Aspects (Einteilung und Beurteilung der Kesselspeisewaesser nach neuzeitigen Gesichtspunkten). R. Stumper. Waerme (Berlin), 51: 40, October 6, 1928, pp. 717–723, 6 figs. Quality requirements of feedwater from standpoint of boiler are discussed; criticism of existing methods of analysis; classification of feedwater according to concentration conditions of most importance; recommendations for new classification method based on experimental results.

Dissolved Oxygen in Boiler Water. Power Engr. (Lond.), 23, 272, November, 1928, pp. 418–419, 1 fig. Dissolved oxygen is potential factor in corrosion; in conjunction with other substances in solution it plays important part; pitting is form of corrosion often caused by galvanic action; under certain conditions removal of dissolved oxygen from boiler feedwater appears to be partial remedy for acceleration of acid corrosion and depolarization in electrochemical phenomenon of corrosion by oxygen, and necessity arises for removal of oxygen liberated in boiler as well as dissolved oxygen in feedwater.

Influence of Magnesium Content on Softening of Boiler Feedwater (Einfluss des Magnesiumgehaltes auf die Enthaertung von Kesselspeisewasser). P. Hermann. Waerme (Berlin), 51: 40, October 6, 1928, pp. 755–757, 1 fig. Practical experience with regard to magnesium content is set forth; laboratory tests with solutions of known composition; results of investigation and their practical application.

Water Softening for Locomotive Boilers. Modern transport (Lond.), 20: 500, October 13, 1928, pp. 9–10, 4 figs. New water-softening plant on lime and soda-ash principle at London and North Eastern Railway Company locomotive depot at Annesley; principles of treatment; new feed gear; simplicity of design; tank.

Boiler Feed Water Treatment. Eng. and Boiler House Rev. (Lond.), 42: 5, November, 1928, pp. 244, 246, and 248. Abstract of serial report of Prime Movers' Committee, 1927–28, of National Electric Light Association, giving survey of general progress made during past twelve months.

Comparison of Behavior of Distilled Water and Chemically Purified Water in High-Pressure Boilers (Vergleichende Betrachtung ueber das Verhalten von Destillat und chemisch gereinightem Wasser im Hochdruckkessel). R. Klein. Waerme (Berlin), 51: 40, October 6, 1928, pp. 740–746, 11 figs. Investigation to determine how distillate and chemically treated water influence concentration of boiler water with varying salt content, and losses to be ex-

pected in water, heat, and energy consumption; modern evaporator installations, and treatment of water by thermochemical process are discussed, and charts showing softening process and degasification are presented.

Fundamental Principles of Feedwater-Treatment Processes for Boiler Plants (Grundsaetzliches ueber die Verfahren zur Speisewasseraufbereitung fuer Dampfkesselanlagen). H. Balcke. Waerme (Berlin), 51: 40, October 6, 1928, pp. 747–752. Article discusses in critical manner behavior of chemical and evaporating processes, their advantages and disadvantages in operation of steam power plants.

Practical Points on Feed Water Treatment. J. Guest. Blast Furnace and Steel Plant, 16: 11, November, 1928, pp. 1461–1465, 1 fig. Various methods of treatment are reviewed, both with regard to results attained and routine application; treatment with lime and soda for removing scale-forming solids; chemical treatment applied by both hot and cold processes, both continuous and intermittent in operation; hot process is more rapid, in general, and smaller tanks are necessary than with cold processes; design of tanks; removal of precipitates; zeolites; operating costs.

Present Tendency of Boiler Water Conditioning. R. E. Hall. Power Plant Eng., 32: 21, November 1, 1928, pp. 1136–1138. Prevention of scale, corrosion, and embrittlement and production of dry steam demand definite relations which must be maintained throughout cycle; corrosion in steam lines and turbines is best minimized or eliminated by removal of oxygen or uncombined carbon dioxide from feedwater; essential conditions in water at various surfaces, namely in contact with water below steam temperature, in contact with water and condensing steam, and in contact with boiler and steam generated therefrom. From paper read before American Society of Mechanical Engineers.

Progress in the Production and Treatment of Feedwater (Fortschritte in der Erzeugung und Pflege von Speisewasser). B. Schulz. Waerme (Berlin), 51: 41, October 13, 1928, pp. 765–768, 3 figs. History of development; deaëration process; Morawe degasifier; chemical treatment; raw water; comparison between chemically treated and distilled water.

Salt and Sludge Removal from Boiler Water (Entsalzung und Entschlammung des Kesselwassers). H. Manz. Waerme, (Berlin), 51: 40, October 6, 1928, pp. 726–732, 5 figs. Calculation is given of changes in concentration of soluble salts and sludge in feedwater brought about by boiler operation, and discussion of means of reducing salt and sludge content; their influence on boiler efficiency.

Use of Chemically Treated Water for High-Pressure Boilers (Verwendung von chemisch aufbereitetem Wasser fuer Hochdruckkessel). A. Splittgerber. Waerme (Berlin), 51: 40, October 6, 1928, pp. 733–739, 1 fig. Discussion of principles to be followed in treatment of feedwater, with regard to boiler-

water density, softening, maintenance of soda-sulphate ratio, phosphate addition, salt removal, degasification, etc. for boilers of usual design and for special high-pressure boilers.

Experimental Results with Feedwater Preparation Plants with Evaporators (Versuchsergebnisse an Speisewasseraufbereitungsanlagen mit Verdampfern). SCHWEISGUT. Zeit. des Bayerischen Revision-Vereins (Munich), 32: 20, October 31, 1928, pp. 270–275, 2 figs. Results of investigations to determine influence of load of evaporating plant on purity of distilled water.

The Mathematical Theory of Filtration. A. J. UNDERWOOD. Indus. Chemist (Lond.), 4: 46, November, 1928, pp. 463–466. Mathematical treatment can be of value in providing some means, however approximate, of quantitative treatment; effect of variations in viscosity on rate of flow of liquid; from these equations, final pressure required to filter given volume at given constant rate and time required can be found.

Boiler Water for Locomotives. G. HEARN. Ry. Engr. (Lond.), 49: 586, November, 1928, pp. 424–426. Instructive notes on locomotive feedwater, which treat subject from standpoint of locomotive engineer and give classification of value; analysis of reservoir water. (Concluded.)

White Water Treatment. Paper Trade Jl., 87: 20, November 15, 1928, pp. 49–50, 3 figs. White waters invariably contain valuable fibers and solids, so that their running to waste means material loss; novel recovery and clarification process with new features disclosed in patent issued to R. J. MARX; figure shows diagrammatically, operation of process; mill application.

Power Plants Efficiency Increased by Application of Chemistry. H. C. DINGER. Power, 68: 18, October 30, 1928, pp. 714–716. Author claims that when power plants make as full use of chemistry to secure economy and efficiency as is now made of thermodynamics, long step forward will have been taken; priming, foaming, and contaminated steam; chemical solutions for protecting piping; protective paints and coatings.

Apparatus for Feeding Water and Fuel; Refractory and Other Materials (L'alimentation en eau et en combustible, l'appareillage; les réfractaires et matériaux divers). J. DOUMERC. Technique Moderne (Paris), 20: 21, November 1, 1928, pp. 725–737, 28 figs. Discussion of feedwater, its composition, purification by chemical, thermal, and physico-chemical methods; condenser feedwater, distilled water; feeding apparatus for water and fuel; coal-handling machinery; steam piping and its auxiliaries; valves; heat temperature control and gas analysis apparatus; steam and other meters; furnaces and linings and refractory materials.

Description of Principal Apparatus and Most Recent Installations of Modern Boiler Plants (Description des principaux appareils et des plus recentes installations de la chaufferie moderne). Technique Moderne (Paris), 20: 21, Novem-

ber 1, 1928, pp. 757–792, 68 figs. Description of apparatus and manufacture of boilers, mechanical grates, pulverized-coal equipment, economizers, air heaters, pumps, smoke removers, water distillation, soot blowers and regulating instruments made by various companies in France.

Modern Boiler Furnaces, Boilers, and Accessories (La chaufferie moderne: chaudières et accessoires). C. Roszak. Technique Moderne (Paris),, 20: 21, November 1, 1928, pp. 697–700. Discussion of evaporators, grate, and auxiliaries and condensing group; steam generators, driers, super-heaters, water reheaters, economizers, and heat accumulators are described, also grates, air reheaters, dust collectors, soot blowers, condensers.

Seventh Meeting of the Federation of German Boiler Inspection Societies in Munich, 1928 (VII Tagung des Allgemeinen Verbandes der Deutschen Dampfkessel-Ueberwachungsvereine in Muenchen 1928). A. D. Przygode. Waerme (Berlin), 51: 39 and 41, September 29 and October 13, 1928, pp. 701–708 and 773–777. Review of papers and discussions with varied subjects, such as grounding problems, elevator problems; significance of boiler inspection societies for state organization; application of high-pressure steam, beading of boiler tubes, boiler damages, pulverized fuel, materials testing, etc.

Increasing Durability of Filter Bottoms. G. W. Burke. Water Works Eng., 81: 24, November 21, 1928, pp. 1163–1164, 2 figs. Experiments with cemented gravel slab and that bound with bitumen; cement dissolved in water; durability of bitumen; disintegrating action of water; table showing effect of water on slab specimens; slab bound with air-blown bitumen used.

Early Experience in Design and Operation of Eastern Water Purification Plants. C. A. Brown. Hydraulic Eng., 4: 11, November, 1928, pp. 673–675, 680–681 and 698–699. Experimental plant and results of experiment are described; advent of mixing chamber; filter-plant claims; importance of operation; low-service meter; filter-meter controller.

On the Use of Water Softener. A. C. Embshoff. Power, 68: 21, November 20, 1928, p. 847. Letter to editor replying to article by E. O. Lesseid in November 6, issue of same journal taking exception to his recommendations; it has been writer's experience that when makeup water to cooling system is to be softened, most desirable results are obtained when makeup is softened in zeolite softener.

Hydrogen-Ion Control in Water-Softening. J. R. Baylis. Indus. and Eng. Chem., 20: 11, November, 1928, pp. 1191–1194, 7 figs. Saturation equilibria of hydroxides and carbonates of calcium and magnesium; determination of saturation equilibrium of calcium and magnesium carbonates; effect of temperatures; use and practical application of pH in water softening.

NEW BOOKS

On Water. A Year Book for Water Chemists and for the Technology of Water Treatment. Issued by the Association for Water Chemists of the German Chemists Society. Vol. 2, 1928. Publisher, Verlag Chemie. Berlin W 10, Germany. Price 16 marks. The present volume is an instructive proceedings of the meeting of water chemists in Dresden, Germany, during 1928. The volume was prepared under the editorship of Dr. Bach and contains valuable papers and discussions on a variety of topics of interest to water works authorities. Papers on the progress and the purification of surface waters; the chlorination of drinking water, swimming pools and sewage; the determination of *B. coli* in drinking water; boiler feed water supply; purification of water for laundries; sewage purification in Berlin and Dresden; sewage purification in fish ponds; the digestion of sludge and gas collection; and a number of details in the technique of water examination and minor problems of sewage treatment. Practically all of the well known German investigators in water and sewage purification contribute to the volume. This contribution is of particular importance to American investigators in that it is the aim of this group to standardize methods of water and sewage examination in Germany and ultimately to bring about jointly with workers in the United States the internationalizing of standard methods of analyses. This latter program in a considerable measure is the result of a movement initiated by George W. Fuller during his trip to Germany in the early winter of 1926.—*Abel Wolman.*

I. The Question of Chlorination and Dechlorination During Sterilization of Water. II. The True Free and Apparently Free Active Chlorine in Solution and Its Detection. Karl Bauer, Franz Noziczka, and Otto Stüber. **Abhandlungen aus dem Gesamtgebiete der Hygiene.** Roland Grassberger, Ed. Publ.-Franz Deuticke. Leipzig, Ger., 1928. The chief points of interest in this bulletin are: (1) That chlorinated solutions often contain residual action chlorine in at least two distinct forms, viz., *oxidative* and *antiseptic*. (2) That nitrogenous compounds possess demands for chlorine which vary in some instances almost quantitatively in proportion to the increased concentration of the chlorine and material present. (3) That carbonaceous compounds containing no nitrogen—such as dextrose—show relatively little if any demand for chlorine. (4) That residual chlorine "loosely held" in combination with certain organic compounds, i.e., the antiseptic chlorine—possesses germicidal properties dependent upon the character of the compounds but can not be depended upon for efficient or prompt disinfection, whereas true "free" chlorine, i.e., oxidative chlorine, must be present to insure efficiency of chlorination. (5) The investigators, remarkable as it may seem, fail to find the ortho-tolidin or the benzidine methods satisfactory indicators for oxidative residual chlorine. Rightly enough, the acid-iodide titration with thiosulphate and starch indicator, is held to indicate "loosely bound" chlorine in addition to the so-called "free" chlorine and for this reason has some usefulness. (6) A new method for determination of residual "free" chlorine consisting of titrating acidified samples with a standardized solution of methyl orange is proposed as the most accurate of all methods yet avail-

able. (7) The disclosure of chief interest to the reviewer, and one having considerable bearing on the question of the effective oxygen demand *reduction* of sewage effluents by chlorination, is the proof that the chlorine absorbed produces substitution products from nitrogenous compounds and thereby completely changes their nature. The new compounds are not good bacterial culture media and they possess, moreover, distinct antiseptic qualities evidenced by the destruction of organisms introduced subsequent to chlorination.

The Reaction of Chlorine on Certain Compounds in Dilute Solutions. Chlorine reacts with glycocol—one of the simplest amino compounds—to displace six of the hydrogen atoms in the amino group. Of this combined chlorine 66 per cent is "loosely held," or antiseptic, and reacts positively to acidified starch iodide, but none is oxidative. Anilin absorbs 7 atoms of active chlorine but only 14 per cent can be identified as "loosely held" and none as oxidative. Chlorinated phenol solutions show the presence of "loosely held" chlorine in addition to oxidative chlorine. Acetic acid, lactic acid and dextrose (corn sugar) show no affinity for chlorine.

Extremely interesting disclosures are those in connection with chlorination of a solution containing five one-hundredths of 1 per cent of a solution of nutrient bouillon culture broth. Chlorine application sufficient to produce residual *oxidative* chlorine in the broth solution shows a chlorine demand of 2.7 p.p.m. (fifteen minutes contact). By test for "loosely held" plus oxidative chlorine (thiosulphate titration) the demand was only 0.6 p.p.m. or less. Longer periods of contact showed relatively little increase in chlorine absorption by either test unless the residual *oxidative* chlorine was in excess of 1 p.p.m. There appears to be a stoichiometric relationship between the concentration of chlorine added and the chlorine absorbed. Of the total 2.7 p.p.m. chlorine *absorbed* 66 per cent was found to be "loosely held" and 34 per cent was "fixed." Increasing the dosage of chlorine applied produced an increase in chlorine absorbed as determined by differences in the residual.

It appears that residual chlorine passes gradually from the oxidative through the "loosely held" to the fixed state as per the following observations:

	TOTAL CHLORINE ADDED		
	Residual, oxidative	Residual, loosely held	Chlorine fixed
	per cent	*per cent*	*per cent*
After 15 minutes' contact	28	50	22
After 8 hours' contact	3	52	45

The difference between apparent "free" residual chlorine as disclosed by the ortho-tolidin vs., the thiosulphate titration is not new, nor is the conclusion that residual *oxidative* chlorine as indicated by the ortho-tolidin test is essential in control of sewage chlorination. Since no acknowledgment is made of the work of Tiedeman[2] in 1925–26 at Huntington, Long Island, or that

[2] Ortho-tolidin and starch-iodide tests for free chlorine in sewage tank effluents. W. V. D. Tiedeman, Jour. Amer. Water Works Assoc., vol. 15, April, 1926, p. 391.

of other investigators we assume that the authors are not aware of the American investigations.[3] The work reported does not convince the reviewer that the methyl orange titration is as satisfactory or as practical as the ortho-tolidin test for determination of residual chlorine, or for control of plant operation.

The following would seem to indicate discrepancies in residual chlorine determinations by the starch iodide method. In instances the acid starch-iodide titration showed residual chlorine values of 1.4 p.p.m. when no oxidative residual was detected, and 2.2 parts when the oxidative residual was but 0.1 part. In other words, the apparent residual indicated by iodine liberation was 22 times that actually present in a form capable of producing prompt bactericidal action.

The observations relative to the production of definite antiseptic chlorination products from putrescible bodies is a step in a most interesting direction, not only in the field of water purification, but more especially in sewage chlorination. On this account the work deserves particular attention.—*L. H. Enslow.*

Missouri River. Surface water supply of United States, 1924: pt. 6, Missouri River Basin. NATHAN C. GROVER, W. A. LAMB, ROBERT FOLLANSBEE, C. G. PAULSEN, J. B. SPIEGEL, H. C. BECKMAN, and H. B. KINNISON. 1928. Water-supply paper, 586. U. S. Public Documents, December, 1928.—*Arthur P. Miller.*

Gulf Coastal Plain. Surface water supply of United States, 1924: pt. 8, Western Gulf of Mexico basins. NATHAN C. GROVER, C. E. ELLSWORTH, 1928. Water-supply paper, 588. U. S. Public Documents, December, 1928. —*Arthur P. Miller.*

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[3] Comments on methods for determination of residual chlorine. L. H. Enslow. Sewage Works Journal, vol. 1, no. 1, October, 1928, page 30 et seq. Proc. Second Annual Conference, Maryland Water and Sewage Assoc., Baltimore, Md., April 10–11, 1928.

APPLICATION FOR MEMBERSHIP
IN THE
AMERICAN WATER WORKS ASSOCIATION

Date:...

...................................hereby make application for...

Membership in the American Water Works Association, and enclose herewith the sum of...Dollars, the required initiation fee and one year's dues in advance.

Name..

Title or Business...

Address...

....

....

Business or Professional Experience..

....

....

....

Recommended by...

Recommended by...

Send application to American Water Works Assn., 29 West 39th Street, New York, N. Y.

(To fill in blank see extracts from the Constitution on other side)

REPORT OF MEMBERSHIP COMMITTEE

We have investigated the qualifications of the applicant, and approve his admission to...membership.

Date:.. ....Chairman.

Date:.. ....

Date:.. ....

ARTICLE III. OF CONSTITUTION

Section 3. An Active Member shall be either a superintendent, manager or other officer of a municipal or private water works; a civil, mechanical, hydraulic or sanitary engineer, chemist or bacteriologist, including those acting technically as such for, and employed by, Associate Members of the Association; or any qualified person engaged in the advancement of knowledge relating to water supply in general. (Initiation Fee, $5.00; Annual Dues, $10.00.)

Section 4. A Corporate Member shall be a water board, water commission, water department, water company or corporation; national state or district board of health or other body, corporation or organization interested or engaged in public water supply work, and shall be entitled to one representative whose name shall appear on the roll of members and may be changed at the convenience or pleasure of the represented Corporate Member upon written request to the Secretary, and who shall have all of the rights and privileges of an Active Member. (Initiation Fee, $10.00; Annual Dues, $15.00.)

Section 5. An Associate Member shall be either a person, firm or corporation, engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works. An Associate Membership shall entitle the holder to be represented by one person on the floor at each meeting but such representative shall not be entitled to vote nor take part in any discussion unless permission is given by unanimous consent of the members present. (Initiation Fee, $10.00; Annual Dues, $25.00.)

Membership in the Association carries also membership in its Local Sections, and the Journal, a monthly publication devoted to water works interest. The proceedings of the annual conventions and of the meetings of the Local Sections are published in the Journal, which also contains contributed articles on subjects pertaining to public water supplies.